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ABSTRACT

In July, 1967, Governor Harold LeVander established the Governor's Committee on State Information Systems. This committee, chaired by Gilbert A. Holmes, has had considerable impact on recent developments in information systems and computerization in the State government and in higher education. In February, 1970, the committee recommended that the Governor and the Commissioner of Administration proceed with a study to develop a comprehensive State plan for information systems for presentation to the 1971 Legislature. The study is presented in five parts: (1) Introduction, (2) Summary (also available as LI 002 386), (3) State Government, (4) Higher Education (also available as LI 002 387) and (5) Local Government. Except for part I, a detailed table of contents appears at the front of each part of the report. (NH)

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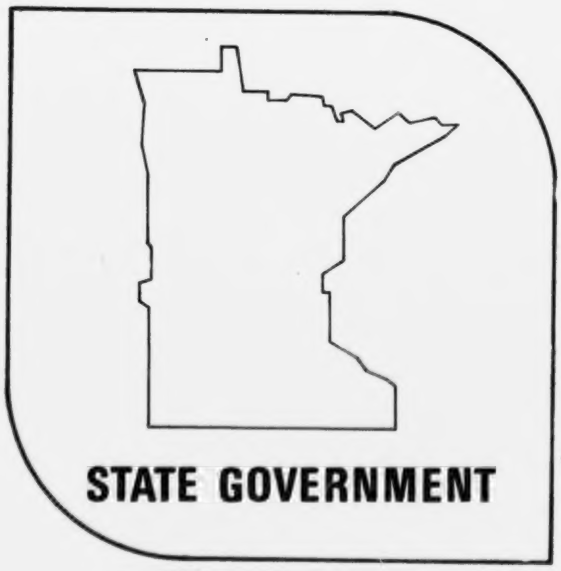
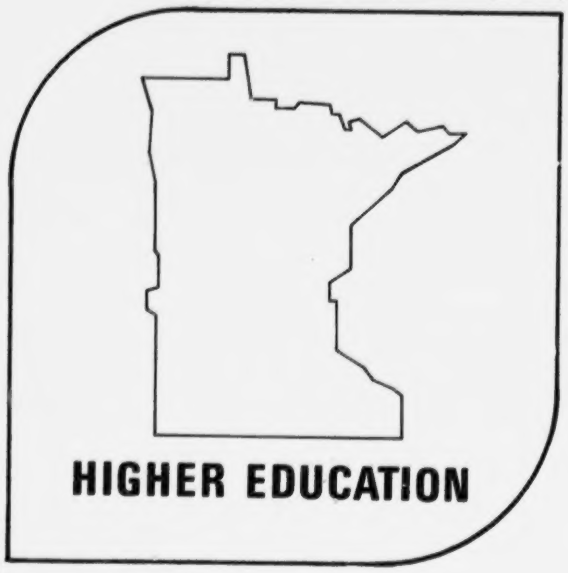
INFORMATION SYSTEMS IN THE STATE OF MINNESOTA 1970-1980



STATE GOVERNMENT



HIGHER EDUCATION

LOCAL GOVERNMENT

LI 002385

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In the higher education part of the study, heavy assistance was obtained from many administrative and academic personnel. Acknowledgement of that assistance is in the prefatory material contained in the higher education part of the report. In addition, Dr. Peter G. Roll of the University of Minnesota was granted a leave of absence to work for the Minnesota Higher Education Coordinating Commission on the project. His work was crucial to the successful completion of the task.

In the local government part of the study, assistance of the staffs of the League of Minnesota Municipalities and the Association of Minnesota Counties was helpful. Commissioner Howard B. Casmey, State Department of Education, and members of his staff were of particular assistance in assuring understanding of school district needs and plans.

Valuable assistance was obtained from four consultants: Dr. William H. Mitchel in certain aspects of local government information systems; Dr. Ronald W. Brady in higher education computer needs; Dr. Russell W. Burris in computer aided instruction; and Dr. Robert M. Hayes in reviewing computer needs of libraries in the State.

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Analysts International Corporation personnel assisting with the study in addition to Dr. Peter C. Patton, the project director, were: John E. Hackley, David W. Kohr, John D. Lonergan, Janet M. Mathiowetz, William H. Osmer, John H. Pemberton, and Edward A. Schneider.

PREFACE

In recent years the substantial implications of the development and implementation of information systems and other computer based services have become quite clear to governmental jurisdictions throughout the State of Minnesota. Public officials and administrators in the State administration, in higher education, and in counties, municipalities, and school districts are taking initiative in bringing the tools of systems analysis and computers to bear on the problems of government.

Both Governor Harold LeVander and the Legislature have provided leadership in efforts to assure the orderly and efficient use of these tools in the State government and in higher education. Moreover, they have indicated interest in the local government problems in these areas.

In July, 1967, the Governor established the Governor's Committee on State Information Systems. This Committee, chaired by Gilbert A. Holmes, has had considerable impact on recent developments in information systems and computerization in the State government and higher education. Since its inception, the Committee has felt the need for a comprehensive State plan for information systems and in February, 1970, recommended that the Governor and the Commissioner of Administration proceed with a study to develop such a plan for presentation to the 1971 Legislature.

The study was to consist of three parts: State government, higher education, and local government. The time and funds available for the study limited its scope and the specificity of its results. Moreover, precise future projections in this dynamic field are not only difficult but probably impossible. For these reasons, the plans presented must be viewed as general guidelines rather than fixed recommendations. Analysts International Corporation, Minneapolis, was selected to conduct the study. Dr. Peter C. Patton of that firm was project director. The study began in March, 1970, and was completed in September. It was financed by the special appropriation for computer acceleration and planning provided by the 1969 Legislature.

Analysts International Corporation
Minneapolis, Minnesota
September 1970

TABLE OF CONTENTS

Description **Page**

PART I INTRODUCTION

PART II SUMMARY

Introduction 2-1
State Government 2-3
Higher Education 2-13
Local Government 2-25

PART III STATE GOVERNMENT

Introduction 3-1
Current Status and Projected Requirements 3-7
Cost/Benefit Considerations 3-23
Minnesota Systems Plan 3-29

PART IV HIGHER EDUCATION

Introduction 4-1
A Summary of Present Computing Facilities and Programs in Minnesota Higher Education 4-11
Goals and the Computer Resources Needed to Meet Them 4-17
Facilities and Costs to Meet the Goals 4-29
Recommendations and Development Schedules 4-51

PART V LOCAL GOVERNMENT

Introduction 5-1
State of the Art in Local Government 5-5
Approach to Local Government Information Systems and Computerization 5-23
Recommendations 5-27

NOTE: A detailed Table of Contents appears at the front of each part of the report except Part I.

PART I
INTRODUCTION

TABLE OF CONTENTS

Description	Page
QUALITY OF LIFE	1-1
THE CHALLENGE TO GOVERNMENT	1-1
Population and Wealth	1-1
Dedication of Resources	1-2
GOALS OF SYSTEMS ANALYSIS AND COMPUTERIZATION	1-2
Direct Cost/Benefit	1-2
Indirect Cost/ Benefit	1-3
Information Systems	1-4
ECONOMIC PRESSURES	1-5
COMPUTER SYSTEMS IN GOVERNMENT	1-5
SUMMARY COMMENTS	1-6

LIST OF FIGURES

Figure		Page
1.1	Population Trends of Minnesota and Metropolitan Area Projected Through 1985	1-2
1.2	Minnesota Per Capita Personal Income	1-3
1.3	Electric Utility Industry Sales in Minnesota	1-3
1.4	Value of EDP Systems Installed by Year of Installation (Estimated Purchase Prices) – Scale A Government Purchases of Goods and Services (Current Prices) – Scale B	1-6

LIST OF TABLES

Table		Page
1.1	Minnesota State and Local Public Employees, 1965-1969, Full-Time Equivalent Basis	1-7

INTRODUCTION

In this introductory part of the report, the general nature of the current challenge to government is stated, with some indications of its dimensions in Minnesota. Then a delineation is made of the role to be played by systems analysis and computerization — by information systems — in meeting that challenge. Finally, the economic pressures requiring systems analysis and computerization are discussed. Projections as to the general increase in governmental expenditures for computer hardware are reviewed.

The growth in the complexity and volumes of requirements for service placed upon government at all levels and the resultant costs are among the phenomena of our time. The growing awareness of the interrelationships between and among the forces leading to requests for service, and a desire to look at the problems jointly rather than severally are, fortunately, further phenomena. In Minnesota, the State government, the higher education complex, and local governments are caught up in the growth, the complexity, the interrelationships, the costs, and all of the other problems related to the almost overwhelming rate and nature of change in society.

In many ways Minnesota has been fortunate — in its natural resources, in its leadership, in its political climate. A summarization of the results of the conditions and circumstances of life in Minnesota and a subjective ranking of the State relative to all others on a number of sociological, political, and economic factors is to be found in a Midwest Research Institute study.[1] In the widely reported 1967 study, Minnesota was ranked second on overall quality of life. Certainly the decisions made by the Legislature and local governing boards and the execution of those decisions by the Executive Branch of the State and local governments over the years have had considerable to do with the high ranking Minnesota enjoys.

THE CHALLENGE TO GOVERNMENT

Nonetheless, improved performance by all levels and agencies of government in the State is necessary to assist in coping with the rapid pace of societal change and the acceleration in demands for governmental service. The growth of knowledge in the physical and social sciences has brought clear evidence of the difficulties and of incipient disasters resulting from failure to understand the ecological or sociological impact of many decisions: the relationships of housing to crime, of health to education, of airports to water tables, of taxation to economic development, and of the above and many more upon each other.

Population and Wealth

All of this is compounded by the population pressure in the State and the greater affluence of its people. Since 1940, Minnesota's population has increased by nearly a million people, increasing from 2.79 million to 3.77 million, or about 35 percent, as shown in Figure 1.1. The geographical shift of the population to urban areas is at least as significant as its growth and is a primary reason for the changing emphasis in governmental programs.

Indicators of the economic changes are many. For example, the Minnesota per capita personal income, as shown in Figure 1.2, increased from $2,436 in 1964 to $3,608 in 1969, or 48 percent. Minnesota production of electrical energy increased at approximately 12 percent a year from 1964 (11 billion kilowatt hours) through 1969 (19 billion kilowatt hours), or 73 percent — see Figure 1.3.

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1. Wilson, John O., **Regional Differences in Social Welfare,** Midwest Research Institute, *1967.*

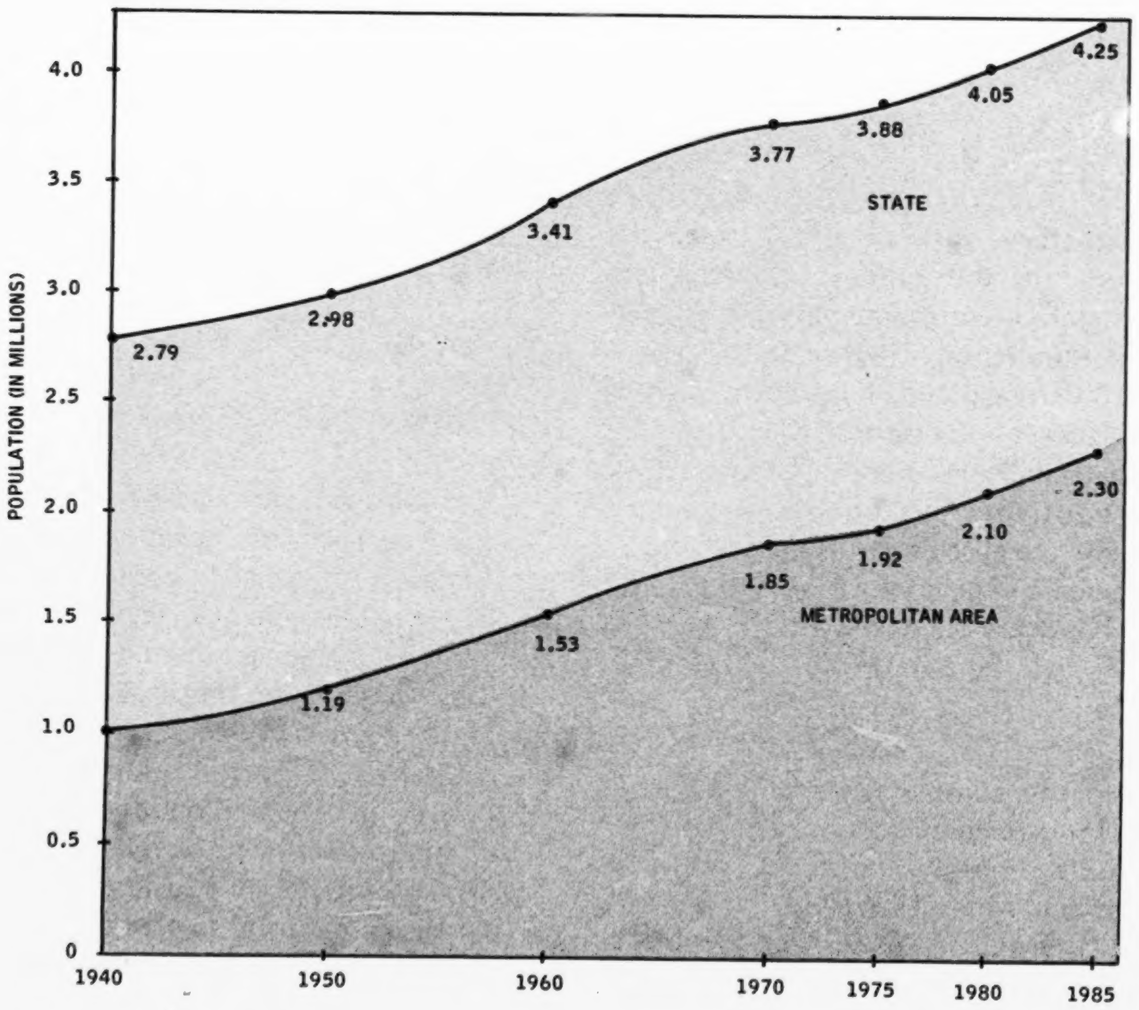


Figure 1.1. Population Trends of Minnesota and Metropolitan Area Projected Through 1985 (Metro Area Includes: Hennepin, Ramsey, Dakota, Scott and Anoka Counties)

Dedication of Resources

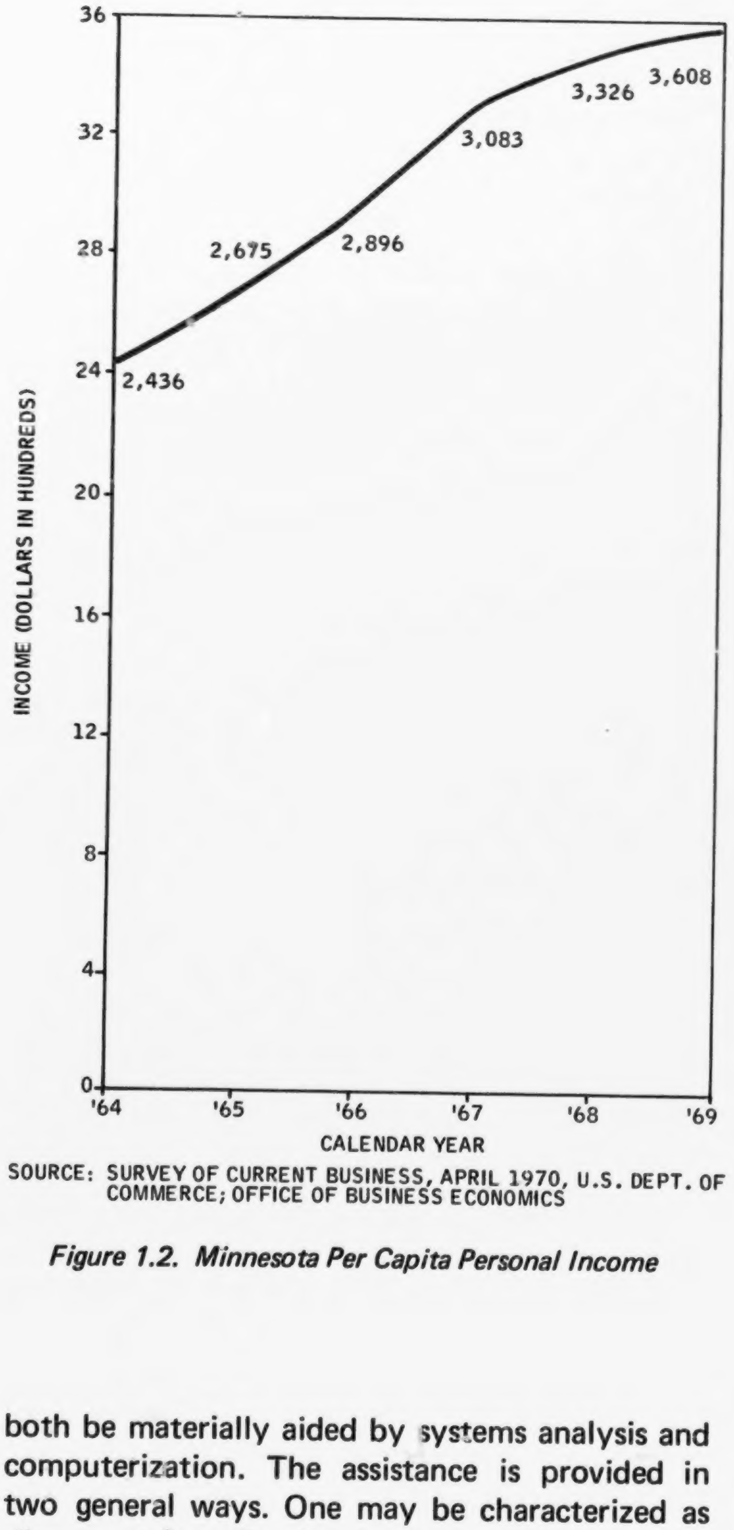
Heavy resources have, of course, been allocated to attack the problems facing society. For the fiscal year 1968, total Federal expenditures were about $179 billion. Estimates for the 1971 fiscal year are at the $200 billion level. Various projections indicate a total annual Federal budget of $230 billion to $236 billion by 1975.

On the State and local government levels, total annual combined expenditures were $86.5 billion in 1965, $94.8 billion in 1966, $105.9 billion in 1967, $107.4 billion in 1968, $118.9 billion in 1969, and $128.8 billion (estimated) in 1970, an average annual increase of 7 percent. Within this period State government expenditures increased an average of 12.6 percent per year for the 1965-67 period. For Minnesota State expenditures, the average annual rate of increase for 1966 through 1971 is 11.9 percent. (See also Tables 2.2 and 2.4 in Section 2 of Part III of this report.)

GOALS OF SYSTEMS ANALYSIS AND COMPUTERIZATION

Direct Cost/Benefit

Decision making in a dynamic society and the cost effective execution of the decisions may



SOURCE: SURVEY OF CURRENT BUSINESS, APRIL 1970, U.S. DEPT. OF COMMERCE; OFFICE OF BUSINESS ECONOMICS

Figure 1.2. Minnesota Per Capita Personal Income

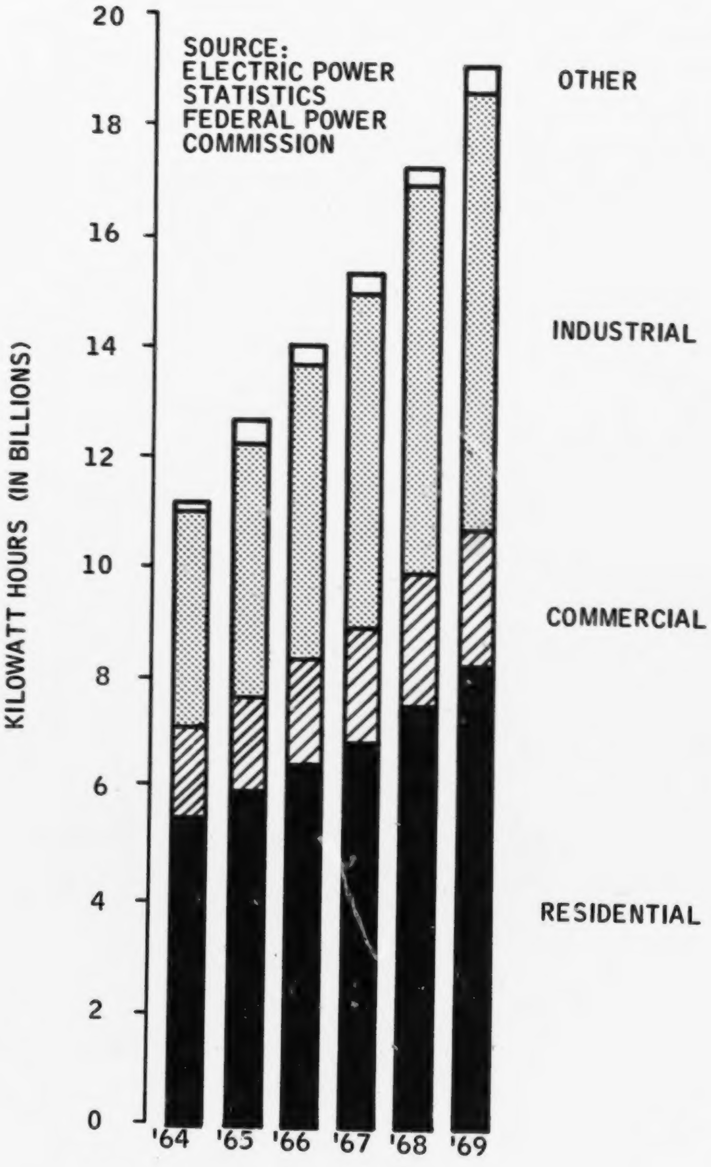


Figure 1.3. Electric Utility Industry Sales In Minnesota

both be materially aided by systems analysis and computerization. The assistance is provided in two general ways. One may be characterized as *direct cost/benefit,* that is, the activity provides a clearly measurable benefit that exceeds the cost of attaining the benefit, such as minimizing the unit costs of processing income tax returns, driver license applications, and motor vehicle license applications; preparing the payroll; manipulating highway engineering calculations; improving the quality and quantity of education by using computers in instruction, etc. Typically, these are operational activities as distinguished from the managerial activities of planning, research, and control.

Indirect Cost/Benefit

A second type of action may be characterized as having *indirect cost/benefit:* for example, prompt retrieval of data on a suspect before attempting an arrest; instantaneous, comparative budgetary analysis for a legislative committee; analysis of probable impact of a change in tax law as an aid in determining tax policy. These provide a benefit that is not clearly measurable but which is estimated to exceed the cost of attaining it. There is obviously real value in safeguarding a policeman's life; in giving legislators promptly more accurate and related information on which to base appropriations; and in providing a sounder basis of information on which to debate tax policy — even though in the short run no direct cost/benefits result. These are often managerial type activities, although the first example is operational.

Information Systems

The term *information systems* reflects the growing understanding of and interest in the application of systems analysis to the administrative functions of society. The term and its increasingly frequent companion, *decision systems*,are in the midst of a semantical storm because of the relative newness of the formalized concepts and the rapidly changing state of systems analysis and computer technology. Generally, however, they reflect the assumptions that: (1) all rational decision making is based on information; (2) the better the information, the better the decision; (3) data gathering, information producing, and decision making should be systematized and then, to the extent feasible, computerized.

It is emphasized here and should be recalled frequently when reviewing this report that the term "information systems" embraces both direct cost/benefit and indirect cost/benefit activities. It should also be noted that operational applications such as processing income tax returns, can also generally provide for the data base needed to satisfy the administrative and planning needs related to that function of State government *if* the systems analysis and design properly consider both types of requirements.

Further, the term *systems analysis* is used to mean an all-encompassing study of all factors relating to a function or an activity including, but not limited to, objectives, organization structure, policies, programs, and the required procedures and methods, both manual and mechanical. The computer itself is simply one of many managerial or mechanical tools that systems analysis may designate as being appropriate to accomplish certain objectives. To put this another way, the computer is a servant of systems analysis, not vice-versa.

Because of its centrality to the whole question of information systems, further comment is offered on the nature of a *data base.* A data base is a set of data upon which an information system, or systems, are based. Often *data bank* is used interchangeably with data base. Quite obviously, a system can produce for informational or decision purposes only what is in the data base or what can be produced as a result of manipulating two or more pieces of data in the data base. In other words, to the extent that data are in the base, they can be retrieved "as is" or reformatted or manipulated as desired for operational or management purposes.

Although a simple concept, it is crucial to any systems analysis. For example, historically the data used for analytical and planning purposes have been collected in an ad hoc fashion. Most of the time of local government employees engaged in such efforts lies in collecting the data, leaving relatively little time for analysis. And even then the data are often outdated or incomplete. At the same time, however, much of the data is generally in the up-to-date operating files of the governmental agencies. In fact, most of the data needed for analysis and planning are in operational files.

Thus, the key consideration in systems design is to assure that the *data elements necessary for all purposes are in fact in the data base.* A few short years ago, it was almost heretical to think in such terms because of the innovative concepts and the data storage costs involved. In the near future it will be commonplace; the new "heresies" will arise with combinations of the new technologies in computing, microfilming, lasers, and chemical memories.

ECONOMIC PRESSURES

The number of services rendered by government has been increasing; at the same time the work loads in virtually all services have been expanding. Intergovernmental requests for data likewise have been increasing and in fact in some cases are a condition of funding. Governmental operating costs, too, have been increasing generally, and more recently inflation has sharply accentuated this trend.

The costs of computer hardware per unit of output, however, have been dropping ever since the first computers were introduced. Radical decreases have been experienced and are still occurring. Recently, a major computer company has announced a new line of computers with estimates of hardware cost reduction per unit of output ranging around thirty percent.

The combination of generally increasing costs and decreasing computer hardware costs is inevitably forcing greater emphasis on systems analysis and computerization for direct cost/benefits. The virtually limitless ability of computers to relate and analyze the vast and increasingly comprehensive data bases and to produce information to aid in decision making are producing significant indirect cost/benefits. The situation is well summarized in the following:

> In just a few short years, questions about whether or not a company should acquire a computer system have virtually disappeared. Today's questions are more nearly "How big a computer do I need?" or "How do I make my computer system work better?" In a hundred percent of the top five hundred companies, and virtually all the rest of American business of any size at all, the systems function has already become as necessary, as much an irrevocable factor of daily business life as marketing, distribution, or production. This instrument (and the extraordinary new notions about the running of a business which come with it) is no longer a luxury for those few who can afford it. It has become a necessity for competitive survival. [2]

COMPUTER SYSTEMS IN GOVERNMENT

Figure 1.4 shows two sets of data from which some important observations can be made. Two of the curves show the annual expenditures for goods and services by the Federal government and by state and local governments. Spending by state and local governments for goods and services surpassed that of the Federal government in 1965; and in 1970, state and local governments spent an estimated $120 billion while the Federal government spent only $100 billion. For the 1971 through 1980 period, spending by state and local governments will increase more rapidly than Federal spending in terms of both the annual rate and the annual amount of increase. By 1980 state and local government expenditures of this type are projected at $278 billion annually, while Federal spending is projected at $155 billion.

The estimated net annual value, at purchase price, of EDP systems installed in the Federal government and in state and local governments is also shown in Figure 1.4. Obviously, government has become a large user of computers and will increase its use substantially. Federal government use far exceeds that of all state and local governments combined. In 1969, for example, the value of Federal government computer hardware is estimated at between $800-850 million whereas the comparable figure for state and local government is $250-300 million. Although there are no published projections of overall governmental computer expenditures, it appears reasonable to assume that such expenditures will increase at a rate at least equal to the increase in spending for goods and services. In fact, for many of the reasons mentioned in this report and with the knowledge that information systems and computerization are in their relative infancy, it is highly probable that the slopes of the computer expenditure curves will be significantly steeper than the slopes of the total goods and services expenditures curves.

It is also indicated that the state-local computer expenditure curve will increase its slope relative

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[2] Ditri, Arnold E. and Wood, Donald R., **The End of the Beginning,** *July 1969.*

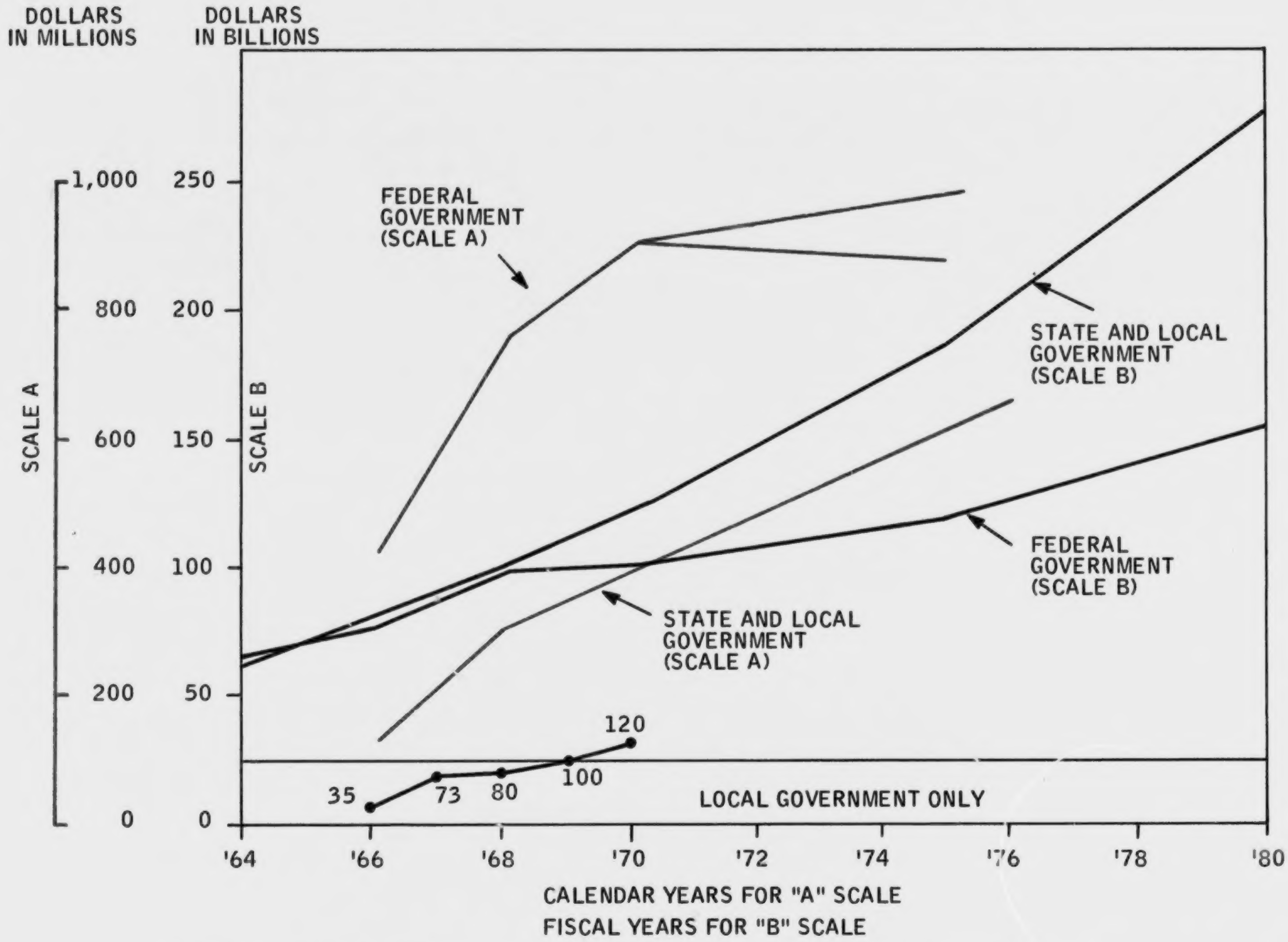


Figure 1.4. Value of EDP Systems Installed by Year of Installation (Estimated Purchase Prices) - Scale A
Government Purchases of Goods and Services (Current Prices) - Scale B

to the Federal curve as the state and local governments move to close the computerization gap between the levels of government.

One measure of the relationship that exists among the three Minnesota entities covered in this report — State government, higher education, and local government — is the full time equivalent employment shown in Table 1.1. Although there is not necessarily a direct relationship between the number of employees and need for information systems and other computerization, there is indeed some relationship. It is clear that local government is where the greatest opportunity lies, particularly in elementary and secondary education, in information systems needs and in computerization as an instructional aid. The four year growth rates in all areas give urgency to the problem.

SUMMARY COMMENTS

The development of systems analysis and computerization technology over the past fifteen years has had a tremendous impact on all phases of business, education, government, industry, and science. The State of Minnesota has been in the midst of these developments. Its computer industry ranks high in the nation. Its State government is among the leading states in the economical development of information systems. Its higher education establishment has moved

Table 1.1. Minnesota State and Local Public Employees, 1965-1969, Full-Time Equivalent Basis

Year	Education			Non-Education			Total		
	State	Local	State and Local	State	Local	State and Local	State	Local	State and Local
1965	11,728	55,878	67,606	22,043	41,775	63,818	33,771	97,653	131,424
1966	13,257	58,994	72,251	22,621	42,560	65,181	35,878	101,554	137,432
1967	14,280	60,016	74,296	22,771	43,420	66,191	37,051	103,436	140,487
1968	15,483	64.185	79,668	24,316	44,165	68,481	39,799	108,350	148,149
1969	17,304	65,407	82,711	24,713	45,513	70,226	42,017	110,920	152,937
4-Year Growth	47.5%	17.1%	22.3%	12.1%	8.9%	10.0%	24.4%	13.6%	16.4%

Source: Public Employment in the United States 1965-1969
U.S. Department of Commerce
Bureau of Census

ahead in implementing computer capability to buttress its instructional, research, and public service activities and to aid in their administration. Its local governments have begun development in this broad area and in one notable effort have set up a coordinated program.

Building on this background, the broad goal of this study is to develop a plan for information systems development and computer utilization in the State of Minnesota for State government, higher education, and local government. Key elements within this plan include the identification of major areas of application and associated benefits, cost projections, and recommendations for legislative and administrative action required for implementation.

The commentary and data presented in this introduction to "Information Systems in the State of Minnesota 1970-1980" have reviewed some of the forces surrounding the development of information systems and the increasing use of computers nation-wide. The goals and concepts of information systems, systems analysis, and data bases were discussed, and the level of governmental expenditures for computer hardware was outlined. Recommendations are summarized in Part 2; Parts 3, 4, and 5 detail the results of the state government, higher education, and local government studies, respectively.

A word of explanation is in order concerning the placement of the area vocational technical schools in the report. The AVTS's are established under the authority of school districts and the State Board of Education. They are also considered as part of higher education of the State and as such are of concern to the Minnesota Higher Education Coordinating Commission. Discussion and recommendations concerning them are in both the higher education and local government parts of the report.

PART II
SUMMARY

TABLE OF CONTENTS

Description	Page
INTRODUCTION	2-1
STATE GOVERNMENT	2-3
Current Status and Projected Requirements	2-4
Information Systems Costs	2-4
Cost/Benefit	2-5
The State Government Systems Plan	2-6
HIGHER EDUCATION	2-13
Computers and the Objectives of Higher Education	2-13
Existing Computing Facilities and Programs	2-14
Goals and Computer Resources Needed to Meet Them	2-15
Facilities and Costs to Meet the Goals	2-17
Recommendations and Development Schedules	2-18
Goals and General Recommendations	2-19
Recommendations for Regional and Statewide Facilities and Programs	2-19
Recommendations Related to Individual Systems	2-20
Recommendations Addressed to the Higher Education Coordinating Commission	2-21
Development Schedules	2-22
LOCAL GOVERNMENT	2-25
Status in Minnesota	2-26
Local Government Recommendations	2-27
General Recommendation	2-28
Organizational Requirements	2-28
Approaches to Cooperative Centers	2-30
Area Computer Centers	2-30
Orientation and Training	2-31
Funding	2-31
Implementation Suggestions	2-32

INTRODUCTION

This part of the report summarizes Part I Introduction and the three substantive parts of the report: III — State Government, IV — Higher Education, V — Local Government. It is intended to serve those who cannot devote time to reading the entire report and to be available for distribution to those not requiring the full report.

The growth in the complexity and volume of requirements for service placed upon government at all levels and the resultant costs are among the phenomena of our time. The growing awareness of the interrelationships between and among the forces leading to requests for service, and a desire to look at the problems jointly rather than severally are, fortunately, further phenomena. In Minnesota, the State government, the higher education complex, and local governments are caught up in the growth, the complexity, the interrelationships, the costs, and all of the other problems related to the almost overwhelming rate and nature of change in society.

Although Minnesota enjoys a high "quality of life" rating among the states, in part attributable to its State and local governments, improved performance in all governmental operations is necessary to cope with the rapid pace of societal change and growing demands for service. Accentuating this are the significant population growth and the increasing affluence of Minnesota citizens. Heavy tax resources have, of course, been allocated to cope with these problems and their demands.

The tools of systems analysis and computerization hold out hope for improving governmental operations, governmental decision making, and the effective execution of those decisions. Realization of these hopes can come through direct and indirect cost/benefits affecting operational and management performance.

The concepts of information systems and decision systems have developed from the growing understanding of the application of systems analysis to the administrative functions of society. These concepts are based on the assumptions that rational decision making is based on information, that the quality of the decision is based in large measure on the quality of the information, and that much decision making is capable of being systematized.

Systems analysis by its nature must include all facets of an activity or function, not only its easily computerizable aspects. Of particular importance is analysis of the information requirements — of the data base that is necessary to provide that information. Computers have made possible the development and management of comprehensive data bases. Moreover, the economics of generally increasing costs on one hand and decreasing computer costs on the other hand are forcing the rapid development of information systems and computerization for direct and indirect cost/benefit. This trend is evident in the present expenditures for computer hardware in government; it can be expected that such expenditures will increase more rapidly than most other types of expenditures and that state and local expenditures for these purposes will increase at a faster rate than in the Federal government.

Each of the three segments covered in this report — state government, higher education, and local government — has considerable significance to the future of the State of Minnesota. It would be futile to suggest that one is qualitatively more important that the others. In a quantitative sense, the full-time equivalent employment data summarized below is one measure of the relative significance.

Although there is not necessarily a direct relationship between the number of employees and need for information systems and other computerization, there is indeed some relationship. On that basis, local government is where the greatest opportunity appears to lie, particularly in elementary and secondary education where both administration and instruction requires computerization.

Viewed on a broad basis, however, the real need is for comprehensive information systems to aid (a) the legislative bodies in setting priorities and funding programs and (b) the administrative officials in executing those programs. The four year growth rates in all areas are evidence of the growing urgency to make optimum use of these new technologies in administration and management.

It should be noted that discussions and recommendations concerning the area vocational technical schools (AVTS) are found in both the higher education and local government parts of the report, reflecting the AVTS's relationships with both the Minnesota Higher Education Coordinating Commission and the State Board of Education.

MINNESOTA STATE AND LOCAL PUBLIC EMPLOYEES 1969 FULL-TIME EQUIVALENT BASIS

	Education			Non-Education			Total		
Year	State	Local	State and Local	State	Local	State and Local	State	Local	State and Local
1969	17,304	65,407	82,711	24,713	45,513	70,226	42,017	110,920	152,937
4-Year Growth	47.5%	17.1%	22.3%	12.1%	8.9%	10.0%	24.4%	13.6%	16.4%

Source: Public Employment in the United States 1965-1969
U.S. Department of Commerce
Bureau of Census

STATE GOVERNMENT

In 1957, the Minnesota Legislature laid the basis for a gradual centralization of the State's data processing facilities by setting up a Central Services Division in the State Department of Administration. In 1960, most of the State's tabulating installations were merged into that division. A principal result of that beginning and the subsequent developments is that Minnesota has avoided much of the extensive and expensive proliferation of computer equipment, personnel, and space that inevitably accompanies separate computer operations.

Like other states, however, the importance of the systems analysis function has not been clearly recognized until recently. Although computer applications were designed, insufficient attention was given to management information; and systems analysis was generally limited to the easily "computerizable" characteristics of a function.

In 1966, the State Planning Agency drew attention to the growing need for information systems for each segment of the State administration. In 1967, the Governor and the Legislature agreed to a $500,000 special appropriation for computer acceleration and set up a Computer Services Division (CSD) in the Department of Administration. The Governor also established the Governor's Committee on State Information Systems, a committee which has played a major role in subsequent developments including calling for this report.

The Governor, by Executive Order in 1968, gave the Computer Services Division broad authority and responsibility in the State's computer efforts. Significant action took place on many fronts in the next two years including another special appropriation by the 1969 Legislature, this time in the amount of $900,000 with $300,000 earmarked for higher education. In 1970, the Governor issued another Executive Order on the subject of information systems, further clarifying the State's direction. Shortly thereafter the Commissioner of Administration reorganized the Computer Services Division, equipping the division to provide better service to its users and to set up a Local Government Unit to assist in local government coordinating efforts. Shortly thereafter, the computer functions of the Department of Highways were merged into the Computer Services Division, leaving only the Department of Manpower Services with a separate computer installation.

Since 1967, significant progress has been made in building the Computer Services Division. The division was strengthened in structure, personnel, and equipment and converted to a heavily multi-programmed operation under full operating systems. Further, extensive progress has been realized in coordinating systems and computer development in State government and higher education.

This part of the study included the Legislature, twelve agencies of the State government, and the three principal retirement agencies. The combination of agencies accounts for over ninety percent of the budget, employees, and computer expenditures of the State, exclusive of higher education. Much of the study effort was devoted to interviews with management personnel of the agencies to determine information needs, both present and prospectively. The results of the interviews were summarized for each department. Inventories of personnel, equipment, and applications were also obtained and analyzed. Departmental informational interrelationships were identified.

CURRENT STATUS AND PROJECTED REQUIREMENTS

From its first IBM 650 computer in 1959, the State computer capacity now consists of two IBM 360-50's, an IBM 360-40, an IBM 360-25, an IBM 1401 (at Manpower Services to be replaced soon by an IBM 360-40), and a UNIVAC 418-II. The first three of these are multi-programmed under full operating systems. One IBM 360-50 and the UNIVAC 418-II operate in communication mode, the 418-II serving as the basis for MINCIS (Minnesota Crime Information System) and interfacing with the 360-40 on which both the driver license and motor vehicle files are maintained.

Four of CSD's largest applications are heavily involved in on-line input, updating, and/or data retrieval: MINCIS, driver's license, motor vehicles, and income tax. The Division's planning assumes that in time most of the State applications will be available for on-line update and retrieval. A wide variety of applications is handled by the Division which services most agencies of the State government.

Effective management of the systems and computer function, of considerable interest to Legislators and top administrators alike, is a complex task. Principal factors are the quality of systems analysis, personnel performance, and efficiency of equipment and its use.

A comprehensive systems approach is necessary in designing cost effective information systems. Too often in the past such an approach has been missing, not only in state government but nearly everywhere. An entire system must be reviewed, not just a portion that someone wants to "put on the computer." This is an extremely difficult task because the management of any significant activity is complex and the systems necessary to assist with that management are also complex. The task obviously cannot be done effectively unless each manager assures himself that the system is in detail what he needs — as an example, not just to account for tax collections, but to give the manager and his principal subordinates what they need for the research, planning, and control aspects of tax administration.

The ratio of hardware cost to total computerization costs in administrative data processing approximated 2 to 1 a few years ago. Now it is typically about 1 to 2. Thus, the management of computer personnel, always a major task, has taken on added relative importance. Controlling the personnel turnover of computer professionals with proven competence and comprehensive knowledge of large and complex systems became critical.

Particular interest has been expressed in the efficiency of computer equipment and its operation. It requires an evaluation of many factors including computer speed and memory size, multi-programming, utilization, scheduling, peripheral equipment, and productive use. Utilization is a particularly difficult evaluation since there is no one definition of utilization which fits all situations. Minnesota State government computers have been generally utilized heavily by any standard in recent years — so heavily that customer service has been occasionally impaired. Recent additions to the State's computer hardware have provided a slight but temporary cushion for additional applications. Completion of all aspects of the recent reorganization of the State computer facilities is necessary to maximize efficiency of operation.

Information Systems Costs

The approximate costs of the State systems and computer operations have increased from $2,000,000 in 1966 to $5,100,000 in 1970. The last three years have shown an increase of about 32 percent a year. The figures are incomplete because costs have not been accumulated statewide, a deficiency to be corrected by a new State accounting system now under development.

A number of factors are expected to lead to constantly increasing computerization spending over the coming years. These include economies of computerization versus manual methods; increases in the volume of State business; additional State services; data requirements of Federal agencies; increasing sophistication in systems design and comprehensiveness of computer services; more productivity from systems and programming personnel; and increase in the State's service to local governments. On the other hand, the growth in comprehensive information systems will put a downward pressure on other costs, both through direct and indirect cost/benefits. To obtain data on which to project future budgets, several factors were reviewed.

- A large number of applications were identified in the course of the study. It was estimated that 497 applications would be in operation by 1975, compared with 332 at present. To reflect increasing complexity and comprehensiveness of new applications, a weighting factor of 2 was assigned to the 265 expected new applications to permit comparison with the present 332. The net results was that the 1975 application load on a basis equivalent to 1970 would be 762.
- The trend in the State's expenditures shown previously amounted over the past three years to an average annual increase of 32 percent.
- A comparison was made of the growth trend in the overall State expenditures and the expenditures for State computer operations. The latter as a percent of the former shows a significant increase over the past five years, a trend almost certain to continue.
- Computer hardware costs among several states (Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin) show that Minnesota is (a) in a middle group on cost per resident although low until 1968 and (b) lowest in cost per state employee in 1967 and 1968 but in 1969 higher than Ohio and equal to Michigan. Such figures are merely indicative since qualitative and performance considerations are omitted. (In fiscal 1970, Minnesota State government information systems costs approximated $1.35 per resident and $207.00 per State employee.)

Although no specific budget recommendations are made, it is suggested that a curve reflecting the estimated increases in applications would be the most likely base for realistic budget planning which, if used, would result in an annual increase over the next five years of about 24 percent. Thus, the 1975 fiscal year would show a total of $14,900,000 compared with the 1970 total of $5,100,000. Budget projection beyond that period was thought to be totally infeasible.

COST/BENEFIT

As a generality, information systems and other computerization efforts will not survive unless cost effective. The measurement of the benefit, however, has often not been made at all or in some cases made incompletely. Among the reasons for this are: costs of existing systems are not known; follow-up on new systems to assure cost/benefit realization often is ignored; new systems bring benefits not previously available; impact of higher workload may be overlooked; inflation's effects may be ignored. Because of the general lack of detailed feasibility studies prior to computerization and the deficiencies in the State accounting system it has not been possible to present an authoritative statement of cost/benefits in Minnesota.

In one example, some facets of income tax processing, it is conservatively estimated that direct personnel cost avoidance since 1964 amounted to the annual amount in 1969 of $230,000. There is substantial evidence that the unit costs of income tax return processing, excluding effects of salary schedule increases, decreased by about 13 percent in that period and this in spite of more extensive and complex processing requirements. A well-documented study of certain Department of Highways engineering tasks showed that pre-automation costs of $2,748,875 were reduced by computerization to $1,129,971, a reduction of $1,618,904 or nearly 59 percent of the original cost. The indirect cost/benefits, such as are to be found in MINCIS and many other systems, will probably far exceed direct cost/benefits.

Minnesota's decision to centralize its computer central processors produces direct cost/benefit. A hypothetical analysis generated a theoretical potential savings of about one-third. Even a half of this potential would provide a large saving when measured against the probable $15,000,000 budget in 1975. But effective administration is necessary to obtain the advantages of such centralization while avoiding its potential disadvantages.

THE STATE GOVERNMENT SYSTEMS PLAN

A plan outlined here for Minnesota State government and designated as MIDS (Minnesota Information and Decision Systems) aims to achieve two primary objectives:

- To make available to the Legislature and to officials of the Executive Branch comprehensive and accurate information in a form and at a time to be of maximum value in decision making and research.
- Provide to all State personnel the most effective framework of systems, procedures, and methods within which to carry out the operations of the State.

The implications of implementing MIDS are enormous. In its broadest terms, MIDS means defining, designing, and installing comprehensive systems for each area of government to serve as the framework for attaining optimum effectiveness of State operations. A major requirement is the ability to associate and interrelate the data bases of the information systems serving major functional areas of government. Corollary to this is the installation of procedures to assure the integrity and confidentiality of data.

Action necessary to implement MIDS is recommended under five headings:

- Comprehensive systems approach
- Organization structure
- Guidelines for development
- Security and confidentiality of data
- Intergovernmental coordination.

A more comprehensive systems approach to the problem of the State. The recommendations are:

- Assignment of overall responsibility for design, coordination, and implementation of MIDS to one agency of the government. Executive Order No. 56 should be interpreted to include *all* systems analysis (not just the computerizable aspects) and incorporated in the State statutes.
- More effective execution by the top executive in each agency of State government of his responsibility for clarifying the objectives of each function of his agency and for specifically approving the general systems required to reach those objectives.
- Attendance by top management personnel of all agencies of State government at intensive courses in systems analysis, information and decision systems concepts, and computer familiarization. Legislators and legislative staff members should be invited to participate.

An organization structure effective in coordinating the design of the many major systems, building efficient operational systems for all areas of State government, attaining maximum productivity from the State's systems and computerization efforts, and providing assistance to Local government. The recommendations are:

- **The State information systems function should be strengthened by improved organization and by statutory centralization in that organization of authority over development and operation of information systems and computerization.** The growing importance of information systems to the operation and management of the State government calls for improving the organization of that function either by further strengthening the structure within the Department of Administration or by establishing a new

Department of Information Systems. For the organizational alternative selected, the most important requirement is that appropriate responsibilities and authority be given to the function. The acronym DIS of this report refers to a Division of Information Systems, and its administrative officer is referred to as Director of Information Systems.

- **All systems and computer functions of the State administration should be administered or controlled by DIS.** This recommendation is consistent with the basic organizational concepts being implemented in Minnesota. Internal organization of the division should be built on the Computer Services Division and should consist of these six sections:

  1. Systems and Programming with present responsibilities broadened to include *all* systems analysis and design, not just computerizable segments of systems.
  2. Planning and Coordination with responsibilities for research, standards, staff development, and higher education coordination as presently but adding two units. One is a Methods Unit to carry out certain systems functions such as forms control, records management, and work measurement and to provide certain systems specialization such as in microfilming. The second is a Management Science Unit to maintain a comprehensive index of all State files, advising and assisting State personnel in how best to obtain and analyze data from those files, and introducing the use of operations research techniques in the analysis of State problems.
  4. Telecommunications Section administering all communications functions of the State.
  5. Local Government Section with primary responsibility to serve as staff to the Intergovernmental Commission on Information Systems recommended in the local government part of this report.
  6. Administrative Services Section carrying out the tasks generally assigned to such divisions in the State. Of particular importance in DIS is the controllership function because of the need for sound data in feasibility analysis and in the cost accounting necessary to the Division's operation.

- **Expenditure Control.** Legislation should be passed to continue in DIS the authority in Executive Order No. 56 to review and approve all proposed expenditures by any agency of the State government for systems development or computerization (equipment, personnel, programs, space, systems design, consultants, service bureaus, etc.) and extension of the authority to cover all systems activity.

- **Governor's Committee.** Legislative action is recommended to formalize the present Governor's Committee on State Information Systems or a similar group to advise the Governor, the Legislature, and DIS on MIDS plans and progress and to recommend on the expenditure of developmental funds.

- **Agency Systems Coordination.** The development and implementation of management systems is a complex matter requiring the attention, coordination, and authority of top management of the user agency. Accordingly, a systems coordinator should be appointed by each major agency of State government, reporting directly to the agency head or to his chief deputy or assistant.

- **Communications Advisory Committee.** Proliferation of communications systems, leading to duplication and overlapping, will result unless coordination is effected. As a vehicle for assuring the needed coordination, it is recommended that a Communications Advisory Committee be established, chaired by the DIS Telecommunications Section head. Membership should include representation from higher education and local government; major State users such as the Department of Highways; and State computer, radio, and telephone technicians.

Planned, controlled development of systems, procedures, and methods — computer-based or otherwise — to optimize the value of data bases and information obtainable therefrom for decision making and research, and to provide the most efficient tools for State employees to carry out the activities of State government.

- **First and foremost is the need for DIS and its user agencies to work together efficiently.** It is axiomatic in this field that only truly cooperative efforts are successful. Specific action that should be taken includes:
    1. Establishment of a MIDS User's Committee to serve as a primary communication device in the implementation of MIDS. The committee should consist of the Systems Coordinator from each of the major agencies of government, the DIS Director, and the appropriate section heads of DIS.
    2. Agency Systems and Computer Planning accomplished jointly by the agency Systems Coordinator and the DIS Major Systems Manager for that agency. It is strongly emphasized that the Systems Coordinator, as agency representative, must assume the key role in planning so the plan will reflect the agency's real needs, not the DIS view of those needs.
    3. Formalized and continuing training programs for agency personnel at the operating level. A spectrum of subjects should be covered including systems; controls; systems conversion techniques; input alternatives; computer techniques for data storage, management, and retrieval; general computer capability; etc.
    4. Formalized methods of communication between DIS and its users. These should include procedures for requisitioning service, for advising on progress, and for reporting on problems.
    5. DIS Newsletter. A simple newsletter, prepared monthly, could be helpful in the continuing orientation of agency personnel to the accomplishments of DIS users and to DIS capabilities.

- **The following guidelines should be adopted for MIDS:**
    1. A systems philosophy aimed at assisting the decision making process as contrasted with simply mechanizing or otherwise improving a production system.
    2. A systems design to permit integrated systems. This requires the development of standard identification systems for persons, organizations, physical assets, etc.; standard data definitions; and standard computer techniques for file management.
    3. Cost/benefit analysis to establish system feasibility.
    4. Computerization developed in an environment based on centralized central processing units and whatever remote terminals are necessary to serve users.
    5. Operational objectives of on-line files for real-time retrieval of information and on-line entry and update of data originating where feasible in the user agency.
    6. Attaining maximum output from both equipment and personnel.

- **The centralization of administration and control of systems development and computerization should be completed.** Specific action necessary to complete the centralization includes:
    1. Transfer of the computer functions of the Department of Manpower Services to DIS. Appropriate systems personnel should remain assigned to MSD, as

with other major departments, to assure systems design responsive to the needs of that department.

2. Developing a schedule for phasing out tabulating machine installations in favor of computerization, including provision for remote terminals where appropriate.

- **Systems activities must be economically justified.** Each systems design which is recommended for implementation – whether to be on a computer or otherwise – must be analyzed, and the feasibility of implementation determined. If feasible, and if implemented, then a planned follow-up must be completed to assure that the "pay-off" was realized or to discover why not.

- **Adequate physical facilities must be provided DIS.** At present the space allocated falls short of minimum requirements. The two computer installations are on opposite sides of the Capitol Mall, preventing optimum use of the computer equipment. Both computer rooms are jammed so full of equipment as to impair the efficiency of computer operating personnel. Neither room is built so that acceptable security standards can be assured. Space assigned to the Centennial Building keypunch section is extremely crowded and generally not conducive to maximum productivity. Space for computer professional personnel is at the crisis point.

- **Personnel costs are constantly growing as a percent of the overall costs of systems development and computerization, with the result that increasing emphasis must be placed on proper management of the staff.** Guidelines in personnel management should include: (a) establishment and enforcement of systems design and programming standards; (b) scheduling and controlling all systems and programming projects; (c) conducting formalized periodic performance reviews; (d) installing training and development programs; (e) assuring competitive posture in classification and salary structure; (f) use of existing systems when practicable; (g) selectively engaging consultants as specialists or to provide overload assistance; (h) assuring comprehensive documentation to maintain continuity. These guidelines in the main have been followed by CSD. The quality of results will be in direct proportion to the supervisory attention given to their enforcement.

- **Computer capabilities of the State will require expansion as the applications increase.** Centralization provides the framework within which that expansion can be done most efficiently. Recommendations related to equipment requirements are: (a) the "Model State Contract" for leasing or purchasing computer hardware should continue to be used by the State; (b) the requirements for compatibility must be given appropriate weight in obtaining additional or replacement equipment; (c) communications networks should be centered on one computer with strong communications handling capabilities; (d) appropriate back-up equipment should be available; (e) to attain the substantial savings available through purchasing rather than leasing, computers and related equipment should be purchased outright or under lease purchase plans when there is reasonable expectation that equipment obsolescence will not occur prior to the breakeven point; (f) peripheral equipment from other than the vendor of the central processing unit should be obtained where cost effective; (g) computer utilization records should be kept on all equipment and should reflect each of the methods of measuring utilization; (h) special emphasis should be placed on evaluation of methods and equipment for input preparation because of its large potential for cost reduction.

- **A number of further actions are necessary in the implementation of MIDS.**

1. Data Dictionary and Standardization of Data Elements. In the recent reorganization, CSD set up the new position of Manager-Standards and Quality with the major objective of

establishing a data dictionary and, corollary thereto, standardizing the structure of data elements and identifiers. Because there is probably no single function more important to the long-range objectives of MIDS, this program must be given top priority and top level support.

2. Controls. No principle in computerization is so basic as the need for controls. GIGO (garbage in – garbage out) has scuttled more computer installations and damaged more user relations than all other problems. It is essential that adequate controls be established; continued failure or unwillingness by any user agency to provide control information or by DIS to establish and administer accuracy controls is a matter for prompt discussion at the Commissioner level.
3. Standards for Systems Analysis and Programming. Standards should be established for all elements of work performed by systems and programming personnel – for example, documentation of existing systems, feasibility analyses, programming conventions, and program documentation.
4. Unified Operational Environment. Many of the remaining second generation programs should be reprogrammed to the third generation computers. In addition, a single set of programming conventions, similarity of operating systems, and standardization of teleprocessing and graphics network and interface control programs must be accomplished.
5. Customer Billing. Development of a new billing system should be given high priority as a major aid to the DIS internal management information system and as an aid in user relations. The new system must, of course, be consistent with both the new State accounting system and the State program budget requirements.

- **Adequate financing is essential.** It is recommended that future funding for all new systems development follow the precedent set in the 1969 special appropriation. That is, all funds for proposed new applications or resystematizing of major existing applications should be included in a special appropriation to DIS. Assuming the continuance of the Governor's Committee on State Information Systems, that committee should advise the DIS Director on the expenditure of those funds. It is also recommended that an amount in addition to that necessary to fund the known new applications be included in the special appropriation for applications where the time table should be accelerated.

  A possible level of funding for MIDS is identified in Section 2 of this part. Additional funding recommended is $3,000,000 for adequate space for DIS, $1,900,000 to assist local government with development efforts – see Part V of this report, and an addition of $250,000 to the computer revolving fund for purchase, rather than lease, of certain equipment.

- **Performance evaluation is desirable for all functions, but it is mandatory for DIS because of the growing impact it has on State government functions and decisions.** An evaluation is already being performed to a limited extent by the State Public Examiner's Office and should continue to be the responsibility of that office.

The development, installation, and policing of subsystems for assuring the integrity of computer-based and all other data and to assure confidentiality of such data by limiting its accessibility only to properly authorized persons.

In this recommendation, attention is focused on the need for assuring integrity of data files by preventing willful tampering with data and by providing detailed procedures for the correction of erroneous data or elimination of obsolete data. Further, and most important, is action necessary to safeguard private rights by establishing procedures to guarantee confidentiality of data. It is emphasized that all data are included, not just computer-based data.

Accordingly, it is recommended that the Legislature enact legislation establishing State and local government policy on integrity and confidentiality of all data and direct the Director of Information Systems and the Intergovernmental Commission on Information Systems (see Part V of this report) to give priority to implementing the policies.

A leadership position in the development and coordination of intergovernmental information systems and of intergovernmental cooperative efforts in systems analysis and computerization. In every way possible, DIS should encourage and participate in intergovernmental efforts. For example:

- Encourage Federal agencies to fund the development and implementation of major information systems for State and local governments.
- Corollary to the above, encourage direct Federal and State participation along with local government in the development and implementation of local government information systems.
- To the extent feasible, promote Minnesota State or Local government agencies serving as prototypes in systems development as suggested above.
- Encourage joint local government development of information systems, assisting where possible with State personnel and funding.
- Promote the utilization of existing, successful applications including individual programs as well as broader groupings of applications.
- Support with personnel and funding any programs of NASIS (The National Association for State Information Systems) to promote common systems, intergovernmental data interchanges, data and operating standards, and any other NASIS efforts furthering State and Local information systems.
- Coordinate and assist with the development of data bases of statewide or regional value, such as MAPS at the University of Minnesota and RAFT developed by the Citizen's League and the Upper Midwest Research and Development Council.

HIGHER EDUCATION

In the State of Minnesota there are five "systems" of higher education, each comprised of numerous separate institutions or campuses distributed throughout the state: the University of Minnesota, the State College System, the State Junior College System, the Area Vocational-Technical Schools, and the Private Colleges. Each of these five systems has as its mission one or more of the three traditional objectives of higher education in the United States: *Instruction,* including vocational, professional, and general education; *Research,* defined as the expansion of knowledge and the development of techniques, methods, and devices for solving problems related to the natural world and to man and his social institutions; and *Public Services* to government and society. The entire thrust of this study has been to determine the computing facility and service needs of Minnesota post-secondary institutions in terms of their particular and diverse objectives, and to find and suggest ways of satisfying these needs which have the greatest likelihood of being implemented. To this end, educators and administrators from numerous institutions in all five systems throughout the state, as well as from other states, were consulted extensively before and during preparation of the report.

The objectives of each of the five major sections of this part of the report are as follows:

- To identify the specific objectives of each of the five systems and the importance of computers in meeting these objectives, both directly as a part of the process of instruction, research, and public service, and indirectly through support of learning resources, student services, and general administrative operation of institutions (Section 1);
- To summarize the existing (1970-71) computing facilities and applications in Minnesota higher education, and their costs (Section 2);
- To analyze the needs of Minnesota higher education for computing facilities and services over the next five and ten years (Section 3);
- To determine the costs of various ways of meeting these needs, identifying the least expensive ways (Section 4); and
- To recommend specific actions by the institutions and systems of higher education and the legislature to meet the identified needs and lay a sound basis for future development (Section 5).

COMPUTERS AND THE OBJECTIVES OF HIGHER EDUCATION

Without going into the detail and citing some of the examples to be found in the complete report, there are few areas of higher education in which computers or information processing systems have not already been applied in some way. Computers are both an object of instruction (for students in computer science, data processing, and other engineering fields) and a tool of instruction in fields as diverse as the basic sciences, social sciences and art and music. One of the few ways in sight to control the rapidly rising costs of higher education, and at the same time perhaps improve its quality, *may* be the as-yet-unproven direct application of information systems to the process of instruction — Computer-Assisted Instruction and Computer-Managed Instruction. In research, computers are similarly an object of study and development in the areas of engineering and information sciences, and an indispensible tool in most research fields of science, engineering, social science, medicine, and many of the humanities. Use of computers in both the instructional and research missions of higher education has overlapped considerably into the public service area already — in-service training for personnel from schools, public agencies, and industry, as well as development of applications to problems of planning and operations in public and private organizations. The potentials for further public service applications of this kind can be substantially increased through suitable communication and coordination between higher education and other segments of society. Finally, higher education is one of the largest "industries" in the State of Minnesota. Its administrative processes are similar to those of any other "industry" group. The economic savings resulting from a coordinated use of computer and information systems in higher education are considerable, just as they are in commerce and industry.

In 1967, a Committee led by John R. Pierce of the Bell Telephone Laboratories issued a report *Computers In Higher Education,*[1] under the auspices of the President's Science Advisory Committee. In addition to presenting a most compelling justification for the substantial use of computer systems in higher education, the *Pierce Report* established a norm for the amount of computer capacity needed — namely, that all institutions of higher education should be at least as well equipped in facilities and programs as were the best-equipped colleges and universities in 1967. Because of the wide disparity between the best and the average in 1967, and because of the generally slow pace of funding since then, these goals are still reasonable ones for Minnesota higher education in the coming decade. The *Pierce Report*[1] is referred to extensively in this study of Minnesota's needs.

EXISTING COMPUTING FACILITIES AND PROGRAMS

The University of Minnesota is the State's largest system of higher education as well as its primary resource for graduate and professional training, research, and public service. It is also the leading state institution in computer facilities and related research and training programs. The University is equipped with a major administrative data processing system which is used to capacity, plus a large system for instruction and research which includes a major computer (the CDC 6600) and several small satellite computers or input/output stations. With the exception of a medium-sized computer serving the Duluth campus, other computing facilities at the University are special-purpose devices built into laboratory apparatus or otherwise dedicated to special applications, and funded almost exclusively by federal or private grants.

With its recent acquisition of a Univac 1106 computer, Mankato State College is surely one of the best-equipped non-PhD-granting colleges in the nation. However, this computer is intended to serve the needs of the other state colleges and outside users as well. Until the magnitude of outside use is established, the adequacy of the 1106 will be undetermined. The remaining five state colleges each have small, obsolete computers with capacities considerably below their present needs for instruction and administrative processing.

The State Junior College System has a small, second-generation computer which provides adequate administrative service for the eighteen junior colleges at present, but with little possibility of expanding the kinds or amount of service. Beginning this year, each of the eighteen colleges is also connected to a commercial time-shared computer service in Minneapolis for instructional computing — the first access they have had for this purpose. These tie-ins were made possible by a $60,000 grant from a special appropriation by the 1969 Legislature to the Higher Education Coordinating Commission.

Data processing curricula are alive and prospering in the three Area Vocational-Technical Schools which have small computers for this purpose. They exist in less prosperous condition at several other schools which make use of small school board computers, or facilities made available on undependable terms by nearby business concerns.

Finally, computing in the private colleges ranges from generously adequate by present standards to zero. Partly by necessity, the private colleges seem to be more involved in cooperative activities among themselves and with public institutions; the Twin Cities College Computer Committee involving seven Twin Cities area colleges and the University of Minnesota is the largest such group.

The table below summarizes order-of-magnitude equivalent purchase costs of existing computer facilities in Minnesota higher education, extracted from Tables 2.1 and 5.1, and from Appendix H.5 of the complete report. The numbers have been rounded to the nearest $100,000 and represent equivalent purchase cost.

University of Minnesota	$ 6,400,000
State College System	2,200,000
State Junior College System	200,000
Area Vocational-Technical Schools	800,000
Private Four-Year Colleges (Est.)	850,000
TOTAL	$10,450,000

Computer industry marketing data is available on a confidential basis to compare Minnesota with other states. Although this information is not an accurate source of total expenditures for equipment, it does provide a reasonably uniform basis for comparison. Among the seven Big-10 midwestern states, Minnesota ranks fifth in public spending for computer facilities in higher education, and fourth in spending among private colleges (Figures 2.1 and 2.2). Compared with the standards established by the Pierce Report[1] which recommended a $414 million national expenditure for computing in higher education, Minnesota ought to be spending about 2% of this amount, or $8 million. Actual equivalent annual lease plus staff, maintenance and operating support is estimated at about $4.2 million for 1970-71 (Table 5.1 plus a generous contribution of $500,000 for all of the private colleges).

GOALS AND COMPUTER RESOURCES NEEDED TO MEET THEM

The goals toward which the analysis of this and the next section are directed are two:

- Achievement of the *Pierce Report*[1] objectives for educational computing in the State of Minnesota, i.e., to provide educational computing services for all of higher education in Minnesota equivalent to that available at the leading universities of the nation in 1967-68.
- Establishment of machine-readable data bases and an administrative data processing capacity which is sufficient to support the management information needs of institutions and systems of higher education and lay the basis for program planning and budgeting.

In this section the computer capacity necessary to meet these goals will be estimated, in terms of the required number of input/output terminals of various kinds, computing power required in statements compiled per second, and the amount of mass data storage needed. The following section will convert these capacity estimates into cost estimates.

The capacity estimates for educational computing are based on the *Pierce Report* breakdown of academic areas into those requiring substantial use of computers, limited use, and casual (very little) use. Following a procedure used in a feasibility study by the General Learning Corporation[2], it was estimated that, averaged over all kinds of students in Minnesota colleges and universities, the computers would need to handle 11.3 problems per year for each full-time equivalent student. Each problem would contain about 70 compute statements to compile. If carried out on a time-shared computer system, between 1.1 and 1.8 hours of terminal time would be required for each problem, depending on the skill of the student. On a batch processing system using medium-speed remote terminals, between three and six runs would be required to complete each problem, depending on the complexity of programming language used. Although such numbers may not be typical of any particular computer used by students, they have been accepted as reasonable estimates of overall use by most of the educators and computer specialists consulted during the course of the study. Further details of the analysis, along with modifications included for junior colleges and area vocational-technical schools, may be found in the complete report and in Appendix H.6. Results are summarized in Table 3.1.

It proved to be more difficult to estimate the computer capacity required to support the administrative data processing needs of Minnesota higher education, because no quantitative national norms or feasibility studies were found to guide the analysis. Therefore, the University of Minnesota, which has the most complete administrative system in the state, was used as a model. Most of the possible administrative applications are in either the operational or planning stages at the University, and the isolated exceptions (a computer-based student registration system, is the major omission) were added on the basis of a crude but reasonable design study. The administrative computing resources required by the other collegiate institutions were estimated then by scaling according to enrollment, staff size or other appropriate application-dependent quantities. (Area vocational-technical schools were omitted from this analysis, since their administrative processing is handled by the school districts to which they are attached — units of local government.) Details of this analysis are explained in Appendix H.6 and tabulated in Table H.6.8, while the results appear in Table 3.2.

The small table below provides a brief summary of the estimated computer capacities required in 1975-76 for all of the Minnesota collegiate institutions — University, State Colleges, State Junior Colleges, and Private Colleges.

Research and public service computing needs have not been included in this analysis. It should be kept in mind, however, that access to sufficient computer capacity is needed by those institutions with missions in these areas, but that the cost of providing such services is normally covered by the outside sources which fund or request them. There were three special computer applications in higher education which merit specific discussion:

TOTAL ENROLLMENT	174,163
EDUCATIONAL COMPUTING	
Batch Processing	
No. Medium-Speed Terminals	90
No. Statements Compiled Per Second	215
Time-Shared Computing	
No. Terminals	1,214
No. Statements Compiled Per Second	1,214
ADMINISTRATIVE DATA PROCESSING	
Mass Storage (millions of characters)	1,992
Required Peak Output Rate (lines per minute)	2,707
Required Peak Computer Processing Rate (transactions per minute)	6,349

- **A Statewide Automated Library System,** which has the potential of substantially increasing the quality of library services available throughout the state, and at the same time controlling an otherwise inevitable cost escalation and service deterioration associated with the explosion in volume of printed information.
- **Computer-Assisted and Computer-Managed Instruction,** which hold promises of substantial increases in the effectiveness and efficiency (cost savings) of higher education if the techniques and technology are carefully and properly developed and applied.
- **Information Services,** building partly upon several research projects at the University and providing ready access and analysis of planning information required by many public agencies and private organizations throughout the State.

The first two special areas listed are sufficiently important to higher education that experts were consulted during the course of this study, and asked to prepare position papers which appear as Appendices H.2 and H.3. The third area is of sufficient interest to other public agencies that it is discussed in the State and Local Government parts of this report.

FACILITIES AND COSTS TO MEET THE GOALS

Having estimated the amount of raw computer power, input/output capacity, and mass data storage needed by Minnesota higher education, the next task is to convert these estimates into reasonable configurations of computer equipment to which costs can be assigned. The largest components of the total cost are the computers themselves. Using benchmark test data from the Auerbach Reports, plus the personal experience of several staff members of Analysts International Corporation, a scale was constructed relating computer cost to computing capacity, as measured by the number of FORTRAN- language statements compiled per minute or data processing transactions executed per minute. (The scale is given in Figure 4.1 and in Table H.7.1 of Appendix 7.) Then this scale was used to convert the previous computer need estimates for Minnesota higher education into cost estimates for three kinds of computer systems:

- Systems supporting only batch processing via local and remote terminals (except for the junior colleges, for which a small, central time-shared computer is less expensive).
- Systems supporting time-shared and batch computing on the same general-purpose computers.
- Separate computer systems to provide batch processing and time-shared computing, using for the latter small computer configurations especially designed to process the short student programs and interactive applications characteristic of much instructional computing.

One observation resulting from this analysis is that instructional time-shared computing can be carried out most economically on a small computer system dedicated to this use. The cost is not much greater than that of the equivalent instructional computing carried out on a large batch-processing computer.

In a similar fashion, a scale was constructed relating the mass data storage capacity of various magnetic disk and drum units to their cost.

A more difficult task was the configuration of remote terminal systems to connect various institutions to central or regional computer systems. The components required for such systems include the computer terminals themselves (input/output devices); modems or data sets to interface these to communication lines; communications controllers to efficiently match the computer to communication lines; multiplexors to concentrate data from or to several terminals over one communication line; and a variety of communication line services available for data transmission. Costs were estimated for a spectrum of each of these components, and then the costs associated with several different geographical deployments of computer and terminal equipment were analyzed for each of the five systems of higher education. Included with equipment costs in these analyses were operating support costs – staff, salaries, supplies and auxiliary equipment, and maintenance – without which no computer system can function. Adequate operating support was estimated from published data and past experience to equal the equivalent lease cost of equipment for educational computing, and to be twice the equivalent lease cost for administrative data processing.

Complete details of this analysis may be found in Section 4 of the report, supplemented by Appendices H.7, H.8, and H.9. Those readers who are not familiar with remote terminal computer configurations and the functions of the many components they contain may find it helpful to refer to Figure 4.2 and its accompanying text. In Table 4.5 are summarized the resulting monthly costs of the various configurations analyzed. The brief table below abstracts the total costs of the least expensive alternatives for the four public systems of higher education. (It was not feasible to include the private colleges in a similar analysis; however, the computer capacity implied here for the public systems is conveniently distributed for access by private colleges.) The costs quoted include equivalent monthly lease of equipment plus monthly operating support.

University of Minnesota System (U-2)	$321,000/month
State College System with Two Central Computers (S-2)	172,000
State Junior College System: Central Administrative Computer plus Time-Shared Instructional Computer (JA-1 plus JI-1)	69,000
Area Vocational-Technical Schools using Regional Centers (instruction only) (V-2)	65,000
TOTAL	$627,000/month
Fully Regionalized Computer Systems (R-1), plus Central Administrative Computer for Junior Colleges	$636,000/month

One of the interesting conclusions from this analysis is that regionalization of computer facilities within higher education does not result, at present, in significant cost savings. The savings in communication line costs are small because of the way institutions are distributed geographically. With a few notable exceptions, these savings are partly offset by increased costs of services from regional computers, which provide many kinds of services rather than specializing in one application for which the system can be optimized (e.g., instructional time-shared computing).

RECOMMENDATIONS AND DEVELOPMENT SCHEDULES

This final section presents:

- a series of recommendations for actions or policies – in general, for each of the five systems of higher education, and for the Higher Education Coordinating Commission;
- a rather specific five-year schedule for developing computing capability in Minnesota higher education, complete with order-of-magnitude cost estimates;
- a more general indication of developments during the second five-year period, 1975-1980;
- some comparative information on other cost figures in higher education to place the cost estimates in perspective; and
- suggestions for priorities and planning to use the funds which may become available.

In a certain sense, the section could be considered a "Master Plan" for computers in Minnesota higher education. The recommendations and funding estimates, however, must be thought of as guidelines; they must not be used as rigid, specific plans. The scope and time available to complete the study have not been sufficient to develop specific, detailed implementation plans, which in any case are the responsibility of the institutions and systems themselves.

As presented briefly in this summary, the recommendations are organized somewhat differently than in the complete report, to emphasize their statewide implications rather than their relation to the institutions with which they may be most directly associated.

Goals and General Recommendations

- Minnesota higher education should attempt to achieve by 1975 a computer capacity for education and administration equivalent to that enjoyed by the best-equipped colleges and universities in 1967. That is, the *Pierce Report* goals should be achieved throughout Minnesota higher education by 1975, and an administrative computer capacity should be established capable of supporting college management information systems and program planning and budgeting.
- It is neither necessary nor desirable to establish full-scale educational programs in Computer Science or Data Processing at all public institutions of higher education.
- Computer installations in higher education must be operated on a service-oriented basis, with instruction and training applications normally scheduled during hours convenient to students. A service orientation, including a meaningful voice for all major users in setting priorities and policy, is *indispensible* for the successful functioning of regional or statewide computer services.
- The capacity for research computing should be available to those institutions with missions including research. Such computing is supported appropriately in the same way as other research activities, and should not require special funding.
- Institutions which train teachers and educational administrators, and the State Department of Education which certifies school personnel, should be requested to establish degree and certification requirements which include appropriate training in computer and information technology and data processing. Future school administrators and teachers in certain fields (e.g., science, mathematics, business education) cannot be considered as adequately prepared for their job without some competence in managing and using information systems and computers.

Recommendations for Regional and Statewide Facilities and Programs

- Existing regional computer centers within higher education should be supported at a level which will permit them to provide adequate regional services. In particular, funds should be provided to expand the communications capability of the University's CDC 6600 computer so that it can service more outside users from remote terminals; and adequate operating support should be provided to the new Regional Computer Center at Mankato State College, so that this experiment in providing computer service to a wide variety of institutions within and outside of higher education has a realistic chance to succeed.
- A Regional Computer Center at St. Cloud State College should begin with a medium-sized satellite computer to the Mankato Regional Center, for installation in 1973. If the Regional Center concept is successful, this satellite would be expanded in 1975 to a full Regional Center. However, this and other expansion in the size or numbers of Regional Computer Centers should proceed only after a careful evaluation of the experience from existing Centers.
- To meet the instructional computing needs of the State Junior Colleges and many private colleges, and the needs of the University of Minnesota for time-shared and other interactive computing, a statewide time-shared computing facility should be established. Initially, this facility would be under the management of one of the systems of higher education – probably the University of Minnesota – but with operating policies established by all users. As the system grows and multiple computers are added, it may be desirable to decentralize the locations and managing institutions, still retaining some statewide

coordination of policies and systems development (hardware and software).

- Planning should commence immediately for a Statewide Automated Library System, based on preliminary work done by the University of Minnesota Library Systems Staff, other libraries, and library groups in the State, and evaluation by Becker and Hayes, Inc. (Appendix H.2). The mechanism to begin this effort should be a Planning Board established by the Higher Education Coordinating Commission, with the mission of developing for the 1971-73 biennium either a complete plan, or interim measures to continue present activities which will contribute eventually to a Statewide Automated Library System.

- To support investigation of the potential effectiveness and economies of Computer-Assisted and Computer-Managed Instruction, a statewide facility should be established to provide computer services and other technical support to development activities at the University's Center for Research in Human Learning *and* at similar centers throughout the State of Minnesota. This statewide support facility would also coordinate development programs in Computer-Assisted Instruction, and aid in their transition from development to operational status.

- Research and development activities associated with information services depending on accurate, continuously-updated, computerized data bases should be supported. It is recommended that the Department of Administration, the University of Minnesota, and other state agencies jointly develop the projects, funding requests, and contracts necessary to implement such development programs which are of potential value to the people of Minnesota.

Recommendations Related to Individual Systems

University of Minnesota

- Special laboratory computers are required for certain professional programs at the University, especially in computer science and engineering. If these programs are to maintain their quality, such laboratory computers must be funded.

- The Coordinate Campuses of the University can most effectively be supplied with computer capacity as follows.

  Duluth — a medium-sized computer, somewhat expanded from the present configuration. If the Regional Computer Center concept prevails, then Duluth would expand into a Regional Center for northeastern Minnesota during the last half of this decade.

  Morris — remote terminals to the University's CDC 6600 and to the statewide time-shared computer facility.

  Crookston and Waseca — terminals to the statewide time-shared computer facility.

State College System

- As soon as possible, each of the state colleges (except Mankato) should be provided with a remote terminal capable of interfacing with both the Mankato Regional Computer Center and the University's CDC 6600. This will enable the colleges to begin providing needed service to their students and administration, and to acquire experience in the remote use of large computers.

State Junior College System

- In addition to instructional computing via the statewide time-shared computer facility, the Junior Colleges require a somewhat larger administrative data processing capacity than they now possess. It is recommended that they acquire a small third-generation computer with adequate magnetic disk storage and an efficient COBOL compiler. Although mail and parcel service has been and will continue to be adequate for most of their data communications, the Junior College Data Processing Staff should, within a few years, begin to develop a remote query system for more rapid access by the individual colleges to certain kinds of information.

Area Vocational-Technical Schools

- Over the next five years, Area Vocational-Technical Schools with programs in Data Processing and Accounting should gather experience in using remote terminals to large computers, and in using business minicomputers which can operate either by themselves for small processing jobs, or as remote terminals to a large computer. It is particularly important for one or two of these terminals to begin extensive use of the Mankato Regional Center as soon as possible, so that experience in working with a center of this kind can be acquired. After a few years of experience with this variety of terminals and computers, it will be possible to make an informed decision on the most effective and economical future direction of computing facilities for vocational training.

Private Colleges

- Technical assistance and advice should be provided by the staffs of the large state-supported computer installations to help the private colleges develop communications interfaces between their terminal and computer facilities and those of the public institutions. In addition, computer systems in the public institutions – most especially the regional and statewide facilities -- should provide services to private colleges at cost.
- Within constitutional constraints, the State should aid the development of computing capacity in the private colleges by supporting regional and statewide computer facilities and data communications networks, and by providing grants to the private colleges to subsidize their use of available computer services. It is recommended that these subsidy grants build up to cover approximately half the cost of the computer services (exclusive of terminal and communications costs) required to meet the educational needs of the private colleges.

Recommendations Addressed to the Higher Education Coordinating Commission

- To increase the efficiency and effectiveness with which its needs for information processing can be met, the Higher Education Coordinating Commission should establish a full-time staff position for an analyst to analyze and advise on program and budget requirements for information and data processing, and to act as a consultant and service manager for applications programming. In addition, remote access to computing facilities and data bases should be made available to Commission staff through the State College Board terminal in the Capitol Square Building.
- It is recommended that the Higher Education Coordinating Commission establish a mechanism to develop standards for the coordination, compatibility, and security of system data bases and applications programs.
- The Higher Education Coordinating Commission should establish a technical committee to develop the specifications, implementation standards, and coordination mechanisms to create and maintain compatible communications interfaces between all terminal and computer facilities in higher education. This effort should be coordinated through the Telecommunications Section of the State Department of Administration with similar standards for other agencies of state and local government.
- The Minnesota Higher Education Coordinating Commission should explore with its counterpart in North Dakota the possibility of sharing computer resources. A reasonable first step in this direction would be to invite a North Dakota representative to participate in the work of the previously-mentioned Technical Committee on Communications Standards.
- An *ad hoc* committee should be established to open channels of communication and

coordination among systems and institutions offering in-service and pre-service training in computing and data processing, and to promote an increase in the amount and geographical distribution of such training.

- The special appropriation of $300,000 by the 1969 Legislature has been most effective in stimulating the development of many useful computer applications and services in Minnesota higher education. It is recommended that such appropriations be continued at a similar or slightly expanded level, that they be made to and disbursed by the Higher Education Coordinating Commission, and that the Commission prepare a report to each session of the Legislature summarizing and evaluating what has been accomplished with the development funds.

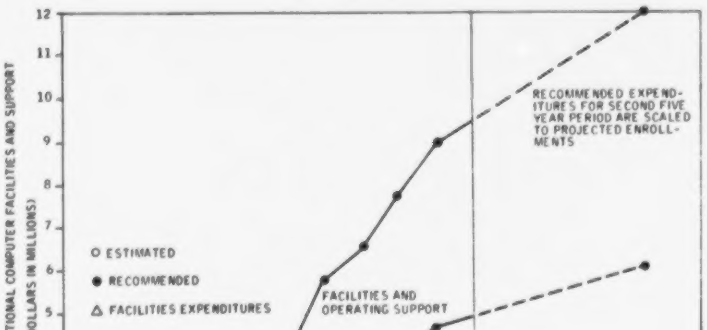
The interrelationships between institutions and systems implied by the preceding recommendations will require a large degree of coordination in developing the facilities and organizations required to achieve an effective and economical computing and information processing capacity in Minnesota higher education. In approving this report, the Higher Education Coordinating Commission has adopted a specific procedural policy to insure the coordination of plans and budgets for computing facilities and services in the various systems and institutions of higher education. A statement of this policy appears following the Recommendations in the complete report.

Development Schedules

Converting the recommendations above into specific facilities and costs for the five years 1970-75 yields the contents of Tables 5.1 through 5.5 in the complete report. The total annual costs estimated for facilities and operating support over this period are summarized in the table below, where the 1970-71 expenditures are those actually planned and committed for that year, and the facilities costs are in terms of equivalent annual lease, regardless of whether the facilities are actually being leased or have been purchased.

Fiscal or Academic Year	Facilities	Operating Support	Total
1970-71	$2,360,000	$1,864,000	$4,224,000
1971-72	2,949,000	2,864,000	5,813,000
1972-73	3,463,000	3,164,000	6,627,000
1973-74	3,997,000	3,754,000	7,751,000
1974-75	4,672,000	4,338,000	9,010,000

The specific facilities recommended for this five-year period are illustrated schematically in Figure 5.1 of the complete report, along with a general indication of the expansion which will be required to maintain an adequate computing capacity during the next five-year period 1975-80. The small graph below is a reduced version of Figure 5.2, presenting the costs summarized in the above table, bracketed on the left by the estimated expenditures for computing in Minnesota public higher education from 1964 to 1970, and on the right by the estimated costs for 1975 to 1980 scaled according to the projected enrollment increase from 1975.



Although the total expenditures recommended are certainly formidable, they appear more reasonable on a per-student basis. If the goals of adequate computing are achieved in 1975, then the cost per student per year, according to the estimates here, would be about $56, compared with $60 estimated by the *Pierce Report* in 1967. The *Pierce Report* also points out that the cost of library services in colleges and universities was between $50 and $200 per student per year in 1966, and the cost of chemistry laboratory instruction was about $95 per chemistry student per year. The $8.8 million for computing recommended for 1974-75 is about 2.5% of the total operating costs estimated for public higher education in Minnesota for that year, compared with 4% of operating costs recommended nationally for computing in higher education by the *Pierce Report.*

Despite these indications that the expenditures recommended here are reasonable, it is clear that, when balanced against other demands on the tax dollar, it may not be possible to achieve the desired computing capacity in higher education as early as 1975. If support cannot be provided at the level recommended, then it is the opinion of the authors of this report that priorities for spending available funds should include support for the existing facilities; establishment of a limited-capacity statewide time-shared computer facility to serve existing needs in the Junior Colleges, the private colleges, and the University; and establishment of a center to support development work on Computer-Assisted and Computer-Managed Instruction throughout the state. However, it is properly and ultimately the responsibility of the individual institutions and systems to higher education to plan the facilities and programs in detail and to set the priorities jointly. The policy for planning and budget coordination adopted by the Minnesota Higher Education Coordinating Commission as a result of this study establishes a sound mechanism to accomplish these tasks.

LOCAL GOVERNMENT

In large measure, local government is where the "action" is. It is here that many of the domestic issues are centered, and it is here that much of the governmental service to the public is rendered. It is also at the local government level that the science and art of systems analysis and computerization can be of most assistance to public administrators in effecting both better service and economies.

Local governments have generally lagged behind the Federal and State governments in such efforts. But there is a growing interest and concern among local governments; the question is how best to approach the overall problem. With few exceptions, "go it alone", uncoordinated efforts by local governments will not get the job done. The extent of the job in Minnesota is 87 counties, 139 municipalities of 2,500 population or greater, and 440 elementary-secondary school districts.

In Minnesota, the problem has been recognized by the Legislature, the Governor, the Governor's Committee on State Information Systems, the State Commissioners of Administration and Education, and others. The Legislature considered legislation relating to local government computerization at the 1969 session and has continued its interest since the session. The Governor in Executive Orders No. 15 and 56 has assigned responsibility to the Computer Services Division in developing local government information systems including staff support for systems design and programming and pilot project computerization. The Commissioner of Administration, in a recent reorganization of the Computer Services Division, established a Local Government Unit in the Planning and Coordination Section of that division. The Governor's Committee on State Information Systems was involved in these actions by the Governor and the Commissioner of Administration, and its chairman believes the local government area offers the greatest potential payoff from information systems implementation. The Commissioner of Education and the State Board have made clear their interest in efficient development and use of computers.

Local government interest has been gradually growing. A State-Local Data Systems Group has been set up to begin work on coordinated efforts in information systems development.

The business of local government is particularly susceptible to assistance from information systems and computerization. The evidence of service such as a birth certificate, building permit, or welfare payment may be produced by a computer. The computer can serve as the repository of the raw material to produce such products; and based on the same data, the computer can provide management information to control program execution and evaluate program performance.

With some exceptions, however, local governments have not been in a position to take advantage of the new technology and are struggling with masses of data in manual files which cannot be focused on current problems in a timely fashion. Further, most efforts to improve the situation have emphasized *how* to do something better rather than looking to the objectives and determing *what* is to be accomplished.

What is needed? Information systems are required to serve operational needs and at the same time generate the data necessary for research and planning and permit interrelationship among systems for both operational and planning purposes. In local government, four data bases, or files, are needed: natural persons, legal persons, real property, and personal property. The data elements in the individual agency files should serve the day-to-day operating needs and planning and research requirements and should be relatable through a master index file, under extremely carefully prescribed controls, to data in other files. To the extent possible, routine decision making should be assigned to the system.

Development and implementation of such systems are sizable tasks and require extensive coordination to assure that intergovernmental information needs are met and to avoid the cost of redundancy. In April 1968, the Intergovernmental Task Force on Information Systems emphasized the need for such coordination in its imaginative and authoritative report entitled "The Dynamics of Information Flow." The Task Force, composed of persons representing Federal, state, and local governments, addressed the needs for intergovernmental data systems and exchange and the means for meeting those needs.

Although there is a substantial amount of information on the use of computers in local government, most of it relates to specific applications in individual government jurisdictions. In fact, a measure of the redundancy, present and potential, of systems design and development cost might be obtained from a review of the literature. There is some evidence in the present trend, however, to make one optimistic about significant improvements in local government information systems and computerization.

Among the hopeful signs is the USAC (Urban Systems Advisory Committee) project administered by the Department of Housing and Urban Development. This project has as its objective the building of municipal information systems that will be of value to jurisdictions other than those in which they are being developed. St. Paul, Minnesota, is one of six participating cities and is developing a human resources information system. Another example is the State-financed MINCIS (Minnesota Crime Information System) and its federally aided adjunct project SEARCH which serve local law enforcement agencies throughout Minnesota.

Several states are responding to the local government information systems problem in ways similar to those recommended herein for Minnesota. For example, both California and Pennsylvania have set up intergovernmental boards to establish guidelines for intergovernmental information systems and computer development. There are also a number of examples of local government cooperative development of computer facilities or data interchanges.

STATUS IN MINNESOTA

Questionnaires were used in an attempt to obtain a picture of county and municipal status in Minnesota. With few exceptions, county and municipal governments are in beginning stages of mechanization or have done nothing. Little cooperative development has occurred. County and municipal governments in Minnesota are generally at the threshold and at a point where coordination and cooperation can be most easily realized.

The situation in school districts differs in some degree from that in counties and municipalities. This appears to be the result of three factors: State Board and Department of Education support of efforts to tackle the problem; the TIES (Total Information for Education System) development; and the interest and action in many school districts on instructional uses of computers. State department financed reports have addressed the problem of coordinating computer facilities for school districts, concluding that centers based on state regions would be appropriate. In July 1970, the State Board of Education adopted a policy statement endorsing the regional concept and a close tie to higher education.

TIES was established in 1967 under the Minnesota Joint Powers Act to provide information systems development services and computer facilities for a group of school districts.

Now totaling 29 school districts with an enrollment of nearly 240,000 students, TIES is providing both administrative and instructional computer facilities. A recent TIES evaluation report summarizes TIES' problems and accomplishments, both of which have been substantial, and concludes that TIES is in the process of "restoring the confidence of its users" and that by "strict adherence to system development discipline, TIES can continue this upward trend and move to new levels of service." It appears that both in scope of service and size, TIES stands at or near the head of the class nationwide in coordinated local government computer efforts.

Local governments striking out on their own in the information systems — computerization maze are destined, with few exceptions, to follow a course that at best leads to marginal results and at worst to disaster. The process begins with a partial feasibility study on mechanizing a few applications which often results in obtaining a small computer, often not suitable for the few applications and totally unsuitable for the information systems task that needs doing. It continues with a staffing search and the first round of implementation which is undertaken in an unrealistic time frame, resulting in badly missed schedules, heavily overrun budgets, and disenchanted users. Ultimately there is something to see, but it has no resemblance to an information system. At this point it becomes clear that the facility is not adequate for the job, leading at some later date to an upgrading to a larger computer resulting in costly re-programming. The data base needed for the information system, however, is still non-existent. Cost/benefit evaluation then proves catastrophic.

In order for effective coordination to exist, however, there must be agreement on certain fundamental principles among the users; or success is imperiled. These include: an information system must be implemented for each service program; highly qualified systems analysts and medium-to-large scale central computer are required; smaller governmental jurisdictions can benefit proportionately to the large; the computer's availability and capacity are important, not its ownership or location; the computer facility is in the nature of a utility; user management must get deeply involved with the necessary comprehensive systems design; common systems development to cover the needs of similar governmental jurisdictions is feasible; programming is a professional matter not requiring the attention of individual jurisdictions; computer management is best left to professionals; priority should be given to systems with largest payoffs; conversion planning is essential; intergovernmental information requirements demand consideration and priority.

Direct and indirect cost/benefits of local government information systems and computerization in Minnesota are not clear and would be in retrospect virtually impossible to determine. It can be said with certainty, however, that a coordinated approach will cost far less than a series of "go-it-alone" approaches. It can be said with virtual certainty that cost trends (costs generally higher but computer hardware costs lower) will make computerization increasingly more attractive economically in the future. It can be said with high probability that the payoff from information systems-based decisions will far exceed other cost/benefits.

A series of recommendations are made to provide a framework within which Minnesota local government can move in an orderly, cost effective way, without delay, toward the development and implementation of information systems and other computerization needs. The organizational recommendations are believed to be most important recommendations in this report.

LOCAL GOVERNMENT RECOMMENDATIONS

Information systems and computerization place substantial demands on legislative and executive groups in local government. The decision to move into these areas is a major one which, taken seriously, requires such officials to define objectives and clearly delineate programs and policies in all functions of government.

Recommendations and guidelines to serve as a plan for accelerating the efficient development of Minnesota local government information systems and computerization are under these headings:

- General recommendation for State policy.
- Organizational requirements.
- Approaches to coperative centers.
- Area Computer Centers.
- Orientation and training.
- Funding.
- Implementation suggestions.

General Recommendation

In summary, it is the strongest recommendation in this report that in 1971 the Legislature establish an Intergovernmental Commission on Information Systems with coordinative authority over all cooperative efforts in local government information systems and computerization. The authorities and responsibilities of the Commission are limited to those necessary to attaining a coordinated, statewide approach to the building of local government information systems and to establish the framework for the orderly and efficient development of cooperative computer facilities. Implementation of this recommendation would call for amending the Minnesota Joint Powers statute (a) to require as a final step, insofar as information systems and computerization are concerned, approval by the Intergovernmental Commission and (b) for any such joint efforts involving school districts the approval of the State Board of Education prior to Commission action. In addition, *developmental funding* by the State on a matching basis with local government is recommended as is Commission control over Federal, State, or foundation funding for all local government information systems and computerization *developmental efforts.* It should be noted that the recommendations are limited to cooperative and coordinated activities; "go-it-alone" efforts by local government are not recommended to be in the purview of the Commission.

Organizational Requirements

A formalized organization structure must be established in order to provide the framework and the machinery for orderly development of local government information systems and computerization.

- An Intergovernmental Commission on Information Systems should be established with coordinative authority over cooperative efforts in information systems and computerization in local government. Only in this way will it be possible to look at the entire problem in a manner that can maximize the cost effectiveness of such efforts. State Board of Education approval should be required for any joint effort of this nature on the part of school districts, prior to submission of the plan to the Intergovernmental Commission. It is believed that through these two steps the statutory responsibilities of the State Board may be met and the necessary coordination be obtained through the Commission. The authorities and responsibilities recommended for the Commission must include *only* those necessary to permit statewide coordinated efforts toward compatible information systems and to assure carefully planned development of computer facilities throughout the state. In addition, the recommended representation on the Commission is designed so as to assure an effective voice for all groups. The recommended responsibilities and authorities of the Commission are:

1. To establish goals and objectives for intergovernmental information systems in Minnesota as well as general policies governing coordination, cooperation, joint efforts, and priorities.
2. To authorize establishment of Area Computer Centers; to promulgate policies and procedures assuring the coordination of the efforts of Area Computer Center Boards, so that an integrated statewide system may

ultimately be developed; to establish (a) criteria for determining economic feasibility for the Centers and the several information systems, and (b) procedures for measuring actual versus expected cost/benefits.

3. To coordinate the development and implementation of standards of compatibility of procedures, programming languages, codes, and media to facilitate the exchange of information within and among systems.
4. To review and approve or disapprove all applications requesting Federal, State, or foundation funding for planning and development of programs with potential impact on local or intergovernmental information systems.
5. To review and comment upon policies affecting intergovernmental information exchange established by the Governor's Committee on State Information Systems and/or the Director of Information Systems and provide advice to the State on long-range policies, programs, and plans relative to intergovernmental information systems.
6. To develop policies and design procedures for the security of data in local government information systems and for safeguarding the confidentiality of such data consistent with state statutes, local ordinances, and pertinent administrative rules and regulations (also see recommendation in Part III on security and privacy).

- It is recommended that the Minnesota Joint Powers statute be revised to require approval of the Intergovernmental Commission on Information Systems prior to establishing any future cooperative effort in information systems and computerization. The reason for this recommendation is that the coordinated and efficient development of a statewide information system has to be accomplished within some general framework. Only the Intergovernmental Commission will have this viewpoint. If this is not done, it will be virtually impossible (a) to avoid the overwhelming cost of redundancy and (b) to develop standardized and compatible information systems.
- In order to attain a true intergovernmental base, members of the Commission should represent all governmental echelons involved with intergovernmental information requirements. Majority representation, however, should be given to local governments as a group. Accordingly, it is recommended that the Commission membership should consist of two persons representing counties, two representing municipalities, three representing school districts, three representing the State Government, and one each from the Governor's Committee on State Information Systems and Minnesota regional government. The State members should be the Director of Information Systems, a representative of the State Board of Education, and a representative of higher education. A Federal government observer should be obtained from a department such as HEW or HUD. It is further recommended that the appointments be made by the Governor, to serve at his pleasure, and that local government representation be made from nominations submitted by the Association of Minnesota Counties, by the League of Minnesota Municipalities, and jointly by the Minnesota School Board Association and the Minnesota Association of School Administrators. Finally, it is recommended that the State Director of Information Systems be chairman.
- It is recommended that the Local Government Section of the Division of Information Systems serve as staff for the Intergovernmental Commission. The advantages of this over establishing a new group are that (a) the necessary interfaces with state agencies will be more readily attainable, (b) staff costs will be minimized, (c) staff specialists from the Division of Information Systems will be more readily available and more effectively

used, and (d) the relationship between the recommended chairman (Director of Information Systems) and the staff should be most effective. The disadvantage is the possibility that the State's interests may be given undue weight, a possibility that the Commission itself should be able to control.

- It is recommended that Area Computer Center be authorized by the Commission and operated by the Area Computer Center Board under broad policies established by the Commission to assure integrated, consistent, and economical systems analysis, programming, and computerization efforts. The Area Computer Center Board, limited to a workable number such as seven, should be elected by the local governmental bodies involved with the Center.
- In those cases where departments of the State government have supervisory or regulatory authority over local governmental functions, it is recommended that requests for Federal, State, or foundation funding for development of intergovernmental information systems or computerization require approval by the State department involved prior to submission to the Intergovernmental Commission for final approval.

Approaches to Cooperative Centers

The only cost effective computer cooperation for most local governments in Minnesota is the common use of systems and computers. The alternative methods are essentially of three types: geographically oriented, such as a county, a group of counties, or a State region; functionally based serving school districts, for example; or a combination such as a State region wherein one Area Computer Center serves all school districts and another serves all counties and municipalities.

Although the recommendation of specific locations is beyond the scope of this study, it is recommended that the presently designated State regions be used as a basis for preliminary planning of Centers. A Center should cover one or more complete regions or a part of a heavily populated region, but not parts of two or more regions.

Major factors to be considered in establishing a Center are: (a) a service base sufficient to justify the center: total population and school enrollment are principal examples; (b) general readiness of the potential clientele to make use of the facilities; (c) adequate financing; (d) contractual agreement as to charges, services, and coordination personnel; (e) geographic area and distances; and (f) communications cost/benefit. These criteria are dynamic because of external forces and because of their mutual interaction.

Area Computer Centers

Against the background of the preceding discussion, specifics of Area Computer Centers are now considered. There are three alternatives that appear to be feasible in Minnesota.

- **A Center created anew under authority of the Intergovernmental Commission.** An example of this type of Center is TIES, in which case twenty school districts set up a new computer center under the Joint Powers Statute, and employed the systems, programming, and operating staff to carry out all phases of development and operations.
- **A Center already existing in higher education.** Certain of the larger higher education institutions have or will have computer configurations with the capacity to handle information systems and computerization requirements of local governments including school districts. Provision of such service would be consistent with the institution's public service objectives. The development of instructional uses by such an institution could be most helpful to school districts. Depending upon developments in type and quantity of utilization over the next few years and the composition of the higher education network as discussed in Part IV of this report, the institution may find that it would be faced with a choice of serving only higher education, limiting its service

to higher education in favor of serving local government, or greatly increasing its computer capacity.

- **A Center already existing in an AVTS.** No AVTS now has a computer configuration capable of handling the kinds of information systems and computerization called for in this report. In fact, most of the present computer configurations in the AVTS's are less than adequate for the educational needs of those schools because of their size and generation. The larger configuration necessary for an Area Computer Center could fill the educational need. Further, the programming and operational requirements of a Center would offer substantial opportunity for excellent student training. The AVTS's, under school district control, are a logical choice to provide service to school districts and their schools. In addition, the AVTS's in many communities enjoy a close relationship with county and municipal governments.

Orientation and Training

Information systems, involved as they are with the broad, complex, and largely innovative concepts of systems analysis and computerization, simply cannot be developed without a significant training effort. Curricula should be established for elected officials, for top and middle management, for supervisory personnel directly involved in services likely to be computerized, and for local government personnel who will form or be the coordinative link with, the information systems cadre.

Educational programs of value to local government information systems efforts should be catalogued and periodically disseminated to local government through the existing channels of the Association of Minnesota Counties, the League of Minnesota Municipalities, and the Minnesota Association of School Administrators.

Of equal or perhaps greater importance is the need for such emphasis in teacher training sequences. Recommendation No. 7 in Part IV of this report states, "The major problem in implementing modern information systems and computer instruction technology in local school districts is a lack of people trained in these fields."

Funding

It appears unrealistic to expect developmental funding by local government alone. Some contribution, however, should be expected from local government, perhaps on a matching basis. Because the need is so great and the time so short, it is recommended that the State make available a substantial sum for developmental work. This money would be available for expenditure by the Director of Information Systems upon recommendation of the Intergovernmental Commission on Information Systems. The funds would be available for developmental purposes. In the main, they should be used to develop or obtain systems and to fund pilot projects, but they should not be available to subsidize an on-going service to a local government.

The amount recommended from the State budget for the next biennium is $1,000,000 for use in development of county and municipal information systems, $700,000 for school districts, and $200,000 as the initial budget for the Local Government Section. The county-municipality sum should be available for use through one or more Area Computer Centers on a matching basis (for example, $3 of state funds for $1 of local funds). The distribution between county and municipal systems should be determined by the Intergovernmental Commission with a principal criterion being early pay-off.

The school district distribution is suggested as a $1 augmentation of school aid per year (or $2 the first year) for all of the students in TIES, approximately 240,000, and all of the students in the second TIES-like Area Computer Center, assuming the new center covers approximately 100,000 students. The money would be made available by the Director of Information Systems to TIES and the new school district Area

Computer Center upon recommendation by the Intergovernmental Commission after reviewing plans for development to be financed by the funds. The TIES suggestion assumes that all TIES systems and programs will be available without charge to other Minnesota jurisdictions.

The amount of money recommended could easily be doubled and spent productively. The odds are high that every dollar invested in this way will return an extremely rewarding pay-off to the taxpayers in Minnesota. It would be appropriate, of course, to seek Federal and foundation funding assistance for both of these efforts. Pooling of resources and efforts among the larger units of local government and the state in specific subject matter areas should also be attempted. In particular the possibility of Federal funding should be aggressively pursued by the Commission, either as a Minnesota project or in combination with other states. Further, joint development action with other states should be explored.

IMPLEMENTATION SUGGESTIONS

Specific action to implement the general recommendations above is outlined below. These actions assume legislative adoption and enactment of the general recommendations made previously. An interim approach is also suggested so that development can proceed prior to such action.

1. The Intergovernmental Commission on Information Systems should authorize an Area Computer Center dedicated to the development and implementation of information systems for county and municipal governments. It is recognized that accomplishing this task may be difficult. However, the local government needs, the availability of some State and/or Federal funding, and significant State technical assistance should provide incentive to a group of progressive jurisdictions.
2. The Intergovernmental Commission should spell out its delegation of authority and assignment of responsibility to the Area Computer Center Board and then conduct an election for the Board.
3. The Area Computer Center Board should appoint a Standards Committee and a Systems Development Committee. The Standards Committee, assisted by the Local Government Section, Division of Information Systems, should undertake the sizable task of drafting a standards manual for local government in Minnesota, including among other things, a data dictionary. Every opportunity should be made available for other local government input. Draft manuals should be circulated to all counties, all municipalities (over 2,500 population), TIES, the Metropolitan Council, and the State Department of Education for review and comment. The initial standards manual should ultimately be presented to the Intergovernmental Commission for approval and would then serve as the local government standards manual.

   The objective of the Systems Development Committee is to obtain or develop sound information systems. The systems selected for initial development should be those with greatest payoff. Further, they should be capable of modular development so that payoff may be realized from part of the system. As with standards, the systems design must be submitted to all jurisdictions for review. Local governments with particular interest, expertise, or accomplishment in related systems should be invited to participate in development of transferable information systems. The Local Government Section should devote much of its effort to the work of this Committee.

4. In the initial stages, the Area Computer Center should make use of a computer capability other than its own. It is expected that only a sizable computer configuration can handle the information systems that will be developed. The Center simply could not utilize such equipment effectively at the outset.

5. The implementation of all except the most proven of existing systems should be limited to one user. Until extensive testing is completed, *no additional users* should be allowed to use a new application. Comprehensive user's manuals *must* be in being prior to implementation.

6. The Area Computer Center Board should develop written policies, regulations, and procedures governing the operation of the Center including a model contract for services; input and output control requirements; security, privacy, and confidentiality of data; charging for services rendered; etc. These should be reviewed and approved by the Intergovernmental Commission inasmuch as they should serve as a pattern for other centers.

7. The Area Computer Center Board, in consultation with the Intergovernmental Commission, should establish an operating plan for the first two years and a corresponding budget.

8. Selection of a director for the center and an appropriate site should be made by the Area Computer Center Board.

9. The Intergovernmental Commission should authorize a second Area Computer Center composed of school districts, preferably be based on a region (MESA and conduct an election of the Board. The Center *should not* begin from scratch but should utilize systems now operational such as TIES or the Honeywell Newport-Mesa, EDINET combination.

Prior to legislative action, the State-Local Data Systems Group and the Local Government Unit of the Computer Services Division should lay as much groundwork as possible for the initiation of the foregoing program.

PART III
STATE

TABLE OF CONTENTS

Section	Page
1. INTRODUCTION	3-1
MINNESOTA BACKGROUND	3-1
Systems and Computer Acceleration	3-2
Executive Order 15	3-2
Executive Order No. 56	3-3
OBJECTIVES AND SCOPE OF THE STUDY	3-4
Agencies Included	3-4
Study Methods	3-4
Agency Relationships	3-6
2. CURRENT STATUS AND PROJECTED REQUIREMENTS	3-7
COMPUTER CONFIGURATION	3-7
OPERATING PHILOSOPHIES	3-7
APPLICATIONS	3-9
MANAGEMENT EFFECTIVENESS	3-9
Systems Design Concepts	3-9
Personnel	3-10
Equipment	3-11
Minnesota Computer Utilization	3-12
COMPUTERIZATION COSTS, WORKLOAD, AND FUNDING PROJECTIONS	3-14
Past Expenditures	3-14
Trends Which Will Affect Future Requirements	3-14
Potential Budget Levels	3-15
3. COST/BENEFIT CONSIDERATIONS	3-23
DOES COMPUTERIZATION REALLY PAY?	3-23
Income Tax Processing	3-23
Engineering Tasks	3-24
Another State	3-24
Indirect Cost/Benefit	3-25
BENEFITS THROUGH CENTRALIZATION	3-25
4. THE MINNESOTA SYSTEMS PLAN	3-29
IMPLEMENTATION OF MIDS	3-29
An Effective Organization Structure	3-30
Planned, Controlled Development of MIDS	3-33
REFERENCES	3-41

LIST OF FIGURES

Figure		Page
2.1	Minnesota State Government Computer Configurations, 1959-1970	3-8
2.2	Projected Workload – State Government Computer Operations	3-17
2.3	Seven State Comparison Estimated Value of Computer Hardware Per State Resident (Based on Purchase Price)	3-19
2.4	Seven State Comparison Estimated Value of Computer Hardware Per State Government Employee (Based on Purchase Price)	3-19
2.5	Expenditures and Projected Funding Trends – State Government Computer Operations	3-20

LIST OF TABLES

Table		Page
1.1	Agencies Served in Fiscal Year 1970 by the Computer Services Division and Selected Agencies in Study	3-5
1.2	Information Interfaces Among the Sixteen Selected State Agencies – Higher Education, Local Government, and Federal Government	3-6
2.1	State Government Average Monthly Computer Utilization by Calendar Quarter	3-13
2.2	Total Costs – Minnesota Systems and Computer Operations	3-14
2.3	State Government Estimate Major Applications by 1975	3-16
2.4	Total Expenditures and Annual Growth Rates for State of Minnesota Government and State Computer Operations (Dollars in Millions)	3-18
2.5	Minnesota Estimated Costs of Computer Hardware and Information Systems Per State Resident and State Employee – 1970	3-20
2.6	Funding Projections for State Government Computer Operations (Dollars in Millions)	3-21
3.1	Minnesota Income Tax Processing, Seasonal Hours vs. Returns Filed (Figures in Thousands)	3-24
3.2	Estimated Cost of Administering Minnesota Income Tax Laws – Fiscal Years 1964-1969	3-24
3.3	Estimated Computing Power as a Function of Monthly System Leasing Costs IBM 360 Series	3-26
3.4	Estimate of Equipment Rental and Other Costs for Six Separate Site Configurations vs. A Centralized Configuration	3-26

1. INTRODUCTION

State governments are playing an increasingly pivotal role in the affairs of the nation. Public service programs, such as natural resources and highways, traditionally state administered, are taking on new dimensions as are programs with heavy Federal overtones administered by or through the states, such as manpower services and welfare. State-local relationships have taken on different meaning as area considerations become more common and as the Congress and Federal agencies look more to the states as intermediate allocators of or advisers on Federal funds for local use.

Information systems play an ever-increasing part in these activities. It has been suggested in the introduction to this report that information systems can be the most important factor in governmental efforts toward the good life.

In this introductory section of the State government part of the report, the background of systems and computerization in Minnesota is reviewed and the approach to this study outlined.

Section 2 summarizes the present status of the State in terms of operating philosophies, personnel, equipment, applications, and costs. Estimates of potential State budgets for those purposes are presented together with historical equipment cost comparisons for selected states.

In Section 3, cost/benefit data are presented. These data include limited, quantitative direct cost/benefits and examples of indirect cost/benefits. Also included are data concerning the cost/benefits of computer centralization.

Section 4 contains recommendations for implementing MIDS, an acronym for Minnesota Information and Decision Systems. The necessary systems approach, organization structure, guidelines for growth, data security and confidentiality considerations, and intergovernmental coordination are included.

MINNESOTA BACKGROUND

In 1957, the Minnesota Legislature enacted legislation establishing a Central Services Division in the Department of Administration. Among the division's several functions was providing tabulating services to departments of the State government. When appropriate space was made available in 1960, tabulating installations from seven agencies of the State were merged and organized within the Central Services Division. Installations in the Departments of Employment Security (now Manpower Services) and Highways and in the offices of elected officials (State Auditor, State Treasurer, and Secretary of State) were not included. The Department of Highways obtained the State's first computer in 1959, an IBM 650. The Central Services Division obtained its first computer, an IBM 1401 card system, in 1962.

A principal result of the centralization accomplished ten years ago has been that Minnesota has avoided much of the extensive and expensive proliferation of computer equipment, personnel, and space that inevitably accompanies separate computer operations. In so doing, Minnesota accomplished in large measure what many states are now beginning to move towards — namely, a centralized, or at least a highly coordinated, systems and computer operation. Although Minnesota was fortunate in its early approach to the computer organization and operation, it did not fare so well in development of its systems philosophy and in laying out its long range plans for systems and computer efforts — shortcomings it apparently shared with all other states.

The systems analysis functions of the State have not been clearly recognized until recently. The design of tabulating and computer systems was generally limited to accomplishing some operational objective. Little attention was directed to management information requirements. Further, the systems were generally limited to the "computerizable" characteristics. Overall systems analyses of activities of government including a review and clarification of objectives and a comprehensive review of all matters pertaining to the attainment of those objectives – such as organization structure, policies, all processes (not just machine related processes), personnel assignment, controls, etc. – simply were not undertaken.

The Central Services Division computer activities were financed and operated under a revolving fund. The division had no funds or personnel available for planning and development effort. Its capabilities and services gradually grew in response to departmental demands, but the division was in no position to give strong direction. Conditions were different in the Highway Department computer operation. Solid management support and adequate financing and staffing resulted in excellent planning.

The growing need for state information systems was recognized by the State Planning Agency shortly after it was organized in June, 1966. In the fall of that year, a report was prepared under contract with the State Planning Agency entitled "A Plan for an Information System for Minnesota State Planning." 1 In the summary of that report is the following paragraph.

> The conclusions from these meetings were that (a) the state has the beginnings of a data base; (b) there remains a large effort to develop a comprehensive data base; (c) computer personnel and facilities must be greatly expanded if the data base is to be fully computerized; (d) top state management is thoroughly receptive to the development of a system, and not resistant to a strong central system; and (e) some state departments are already moving ahead with development of departmental information systems. In short, the state has a long way to go in developing an information system, but the climate in terms of management understanding and support is extremely promising. What is now needed are adequate personnel and computer facilities.

Systems and Computer Acceleration

In 1967, the Executive and Legislative branches teamed up on action aimed at strengthening the state effort. Governor Harold LeVander proposed, and the Legislature enacted, a special appropriation of $500,000 to accelerate computerization of State systems. This legislation required that the computer function be set up as a separate division of the Department of Administration. The Governor then established the Governor's Committee on State Information Systems to advise on the development of the State's systems and computer efforts. The committee, composed of persons from private industry with extensive experience in the management of large systems and computer operations, has played an important role since its appointment in July, 1967.

In January 1968, the Computer Services Division was established in the Department of Administration. Shortly thereafter, the Governor issued Executive Order No. 15 in which he defined the division's objectives as follows:

> To plan the orderly and efficient development of information systems and other computer services for all agencies of the state government; guide the implementation of the plans so that optimum systems and computer integration may be accomplished; administer or coordinate the administration of systems, programming, management science, and computer operations; and provide for controls over accomplishment of the objectives to the end that the State of Minnesota will have a highly effective and efficient overall systems, management science, and computer capability.

The Executive Order also specified broad responsibilities and authority to carry out those objectives.

The results of the order were a gradual beginning toward further coordination and integration of the State's computer development efforts and of activities leading to vastly improved coordination and cooperation in higher education computerization. The Governor's Committee was deeply involved in all of these efforts and was key in their development. Both gubernatorial and legislative support were evidenced in the 1969 Session by a second special appropriation for computer development – $600,000 for the Computer Services Division and $300,000 for higher education, to be spent on authority of the Commissioner of Administration following recommendation of the Governor's Committee.

By the end of 1969, two years after its establishment as a separate division, the Computer Services Division was materially stronger in its personnel and equipment resources. It was moving aggressively and was deeply involved in development, implementation, and operation of advanced systems applications for a number of state agencies. Notwithstanding the general progress and the support and satisfaction of many users, a number of users have been dissatisfied with results of computerization efforts. Dissatisfaction ranged from mild to substantial and resulted from a wide range of problems. Most often the reported problems were a "joint product" of CSD and the user. As a generality, satisfaction appeared to be in direct proportion to the extent of user top management involvement and the systems sophistication of user personnel. An example is the MINCIS (Minnesota Crime Information System) development and implementation which involved and still receives heavy support and participation from Bureau of Criminal Apprehension top management.

Executive Order No. 56

In January 1970, upon recommendation of the Governor's Committee and the Commissioner of Administration, the Governor took a further step to enhance computer development. He issued Executive Order No. 56, superseding the earlier order, making specific his approach in several important areas and directing the Commissioner of Administration to take action to attain greater coordination and integration of the State's computer effort – in the State administration, in higher education, and in local government.

Shortly thereafter, the Commissioner of Administration announced a major reorganization of the Computer Services Division aimed at meeting the division's needs for planning, for control, for operations, for systems design and programming, for coordination with higher education and local government, and for improvement of services to the using agencies. This reorganization has recently been completed. (Parallel to this has been a reorganization of the entire Department of Administration in which the Computer Services Division was renamed the Information Systems Division. In order to avoid confusion with the future organization structure referred to herein, the title of Computer Services Division is used throughout the report.)

The Commissioner of Administration, under authority of Chapter 1129, Laws of 1969, then merged the Department of Highways computer center and staff into the Computer Services Division. This was an extremely important step. Its accomplishment is a tribute to the Governor, the Commissioner of Administration, and the Commissioner of Highways. The latter official's willingness to relinquish control over a large, successful computer operation typifies the cooperative spirit among top State officials that was encountered repeatedly in the course of this study.

Thus, with the exception of the Department of Manpower Services and a few tabulating activities in agencies not under the Governor's authority, Minnesota has centralized responsibility for systems design and computerization and for the development of an integrated information system for the state. The Department of Manpower Services, although administering its own computer center and related activities, is under the computer coordinating authority of the CSD.

It should also be noted that some major departments of government have one or more persons comprising a systems staff in that department to assure systems design responsive to the needs of the department.

Since its establishment as a separate division of the Department of Administration in early 1968, the Computer Services Division has been engaged in a broad variety of activities strengthening the State's systems and computerization capability. Principal among these are:

- Establishing a foundation for more effective internal administration of the division and for improving user relationships by functional reorganization and strengthening staff.
- Reviewing all proposed expenditures on computerization to assure consistency with existing broad State plans and objectives and elimination of duplication.
- Converting virtually all of its operation to a "third generation environment" under full operating systems.
- Attaining a high level of multi-programming (handling more than one task on a computer at the same time) and attaining a high level of utilization of the central computers.
- Implementing in conjunction with users a number of major new systems.
- With the assistance of the Civil Service Department, revising job classifications and pay structure to support the reorganization and to enable the State to compete more successfully for systems and computer personnel.
- Utilizing more systematic and proven methods in systems design and analysis.

During this period, the computer efforts of the Department of Highways continued to produce outstanding results including the implementation of sophisticated computerized systems for the driver license and motor vehicle operations. In summary, substantial progress has been made in recent years, and extensive efforts have been made to coordinate systems and computer developments in the State.

OBJECTIVES AND SCOPE OF THE STUDY

This study has as its primary objective establishing a plan for state information systems. The plan, called MIDS, an acronym for Minnesota Information and Decision Systems, includes a series of specific recommendations and a number of suggested guidelines.

Agencies Included

Time and funds prevented including all State agencies in the study. The sixteen agencies selected are shown in Table 1.1 and included twelve departments from the Executive Branch, the Legislature, and the three principal retirement agencies. Selection was based for the most part on size of the agency in terms of both budget and personnel and on its present and estimated potential need for information systems. The retirement systems were included because of their close relationship to the personnel information system of the Departments of Administration and Civil Service. The twelve executive branch agencies account for over ninety percent of the total State budget, of the State employees, and of State systems and computer expenditures, exclusive of higher education.

Study Methods

A work plan was developed to provide guidelines for the State agency portion of the study. Interviews were held with departmental management to determine information needs. The consultants met each Commissioner or Director of the sixteen selected agencies, the Deputy and Assistant Commissioners, and the Directors of each division in those agencies. EDP Coordinators, where such personnel existed, were most helpful. Additional persons were interviewed as suggested by agency heads.

Following the interviews a position paper was prepared for each of the sixteen agencies. Source

Table 1.1. Agencies Served in Fiscal Year 1970 by the Computer Services Division and Selected Agencies in Study

Legislature*
Supreme Court (Revisor of Statutes)

STATE DEPARTMENTS:

Administration*
Aeronautics
Agriculture
Civil Service*
Commerce*
Conservation*
Corrections
Economic Development
Education*
Health*
Highways*
Iron Range Resources & Rehabilitation
Labor & Industry*
Manpower Services*
Military Affairs
Public Safety*
Public Welfare*
Taxation*

OTHER STATE AGENCIES:

Board of Hairdressing
Board of Nursing
Governor's Office
Mankato State College
Minnesota Higher Education Coordinating Commission
Minnesota Historical Society
Minnesota State Retirement System*
Pollution Control Agency
Public Employees Retirement Association*
Southwest State College
State College Board
State Fair Board
State Junior College Board
State Planning Agency
State Police Officers Retirement Association
State Treasurer's Office
Teachers Retirement Association*
University of Minnesota

OTHER AGENCIES:

Hennepin County
Ramsey County
U.S. Bureau of Public Roads
U.S. Office of Economic Opportunity
Veterans Administration
U.S. Postal Service

*Sixteen selected agencies included in study.

material for these papers included notes from the interviews and publications. The papers described the agency organizational structures and their functions, existing computer systems, systems in the planning or implementation stage, and potential applications that the departments were considering. The interrelationships of each department with other agencies in the study were listed.

The Computer Services Division provided a State inventory of systems and computer personnel and equipment. The Division also obtained detailed descriptions of all computer applications in the State agencies. Included in the equipment inventory were any additional data processing equipment or replacements on order. The personnel inventory included all employees in the EDP section in each department and all management, systems, programming, operations, and data entry personnel in the computer centers of the State. The application inventory included a description of the system, computer time requirements, languages used, and number of programs for each application.

The above data were supplemented by reference to the experience and plans of other states as well as by the consultant staff background in State government.

Agency Relationships

One of the most important factors in the development of information systems is the inter-agency commonality of data. Table 1.2 illustrates the existing information relationships between the selected agencies. In some cases these relationships may be strictly procedural, and in other cases they are highly substantive. In all cases, however, they indicate the requirements for some type of information exchange. The implications of this in the development of information systems are sizable.

Table 1.2. Information Interfaces Among the Sixteen Selected State Agencies – Higher Education, Local Government, and Federal Government

	ADMINISTRATION	CIVIL SERVICE	COMMERCE	CONSERVATION	EDUCATION	HEALTH	HIGHWAYS	LABOR & INDUSTRY	MANPOWER SERVICES	PUBLIC SAFETY	PUBLIC WELFARE	RETIREMENT – MSRS	RETIREMENT – PERA	RETIREMENT – TRA	STATE LEGISLATURE	STATE PLANNING	TAXATION	FEDERAL GOVERNMENT	LOCAL GOVERNMENT
CIVIL SERVICE	●																		
COMMERCE	●	●																	
CONSERVATION	●	●																	
EDUCATION	●	●		●															
HEALTH	●	●		●	●														
HIGHWAYS	●	●		●		●													
LABOR & INDUSTRY	●	●			●	●													
MANPOWER SERVICES	●	●			●	●	●	●											
PUBLIC SAFETY	●	●		●		●	●												
PUBLIC WELFARE	●	●			●	●		●	●										
RETIREMENT – MSRS	●	●	●	●	●	●	●	●	●	●	●								
RETIREMENT – PERA	●	●								●	●	●							
RETIREMENT – TRA	●	●			●							●	●						
STATE LEGISLATURE	●	●	●	●	●	●	●	●	●	●	●	●	●	●					
STATE PLANNING	●	●		●	●	●	●		●	●	●	●	●						
TAXATION	●	●	●		●	●	●	●	●	●		●			●				
FEDERAL GOVERNMENT	●	●	●	●	●	●	●	●	●	●	●	●			●	●	●		
LOCAL GOVERNMENT	●			●	●	●	●	●	●	●	●	●	●	●	●		●	●	
HIGHER EDUCATION	●	●		●	●	●	●		●		●	●		●	●	●	●	●	●

2. CURRENT STATUS AND PROJECTED REQUIREMENTS

COMPUTER CONFIGURATION

Computer operations for State functions are organizationally unified with the exception of the Department of Manpower Services. The personnel and equipment of the Computer Services Division (CSD) are still housed in the same two areas (Highway Building and Centennial Building) occupied prior to the recent organizational unification. The Manpower Services computer staff and equipment are housed in that department's building in downtown St. Paul.

The Computer Services Division computer configuration presently consists of a UNIVAC 418-II, two IBM 360-50's, one IBM 360-40, and one IBM 360-25. Two of the computers are handling telecommunications systems – the UNIVAC 418-II serving MINCIS and an IBM 360-50 handling certain engineering applications. Figure 2.1 shows the gradual development of the state's computer resources since 1959.

The IBM 360-50's and the 40 are operated under full operating systems twenty-four hours a day, seven days a week. One 360-50 has core memory of 384,000 bytes; the other 360-50 and the 360-40 have 256,000 bytes of memory. Over 2.1 billion bytes of random access memory are presently available on the systems. (For purposes of this discussion, one byte may be viewed as one alphabetic character for two numeric characters.)

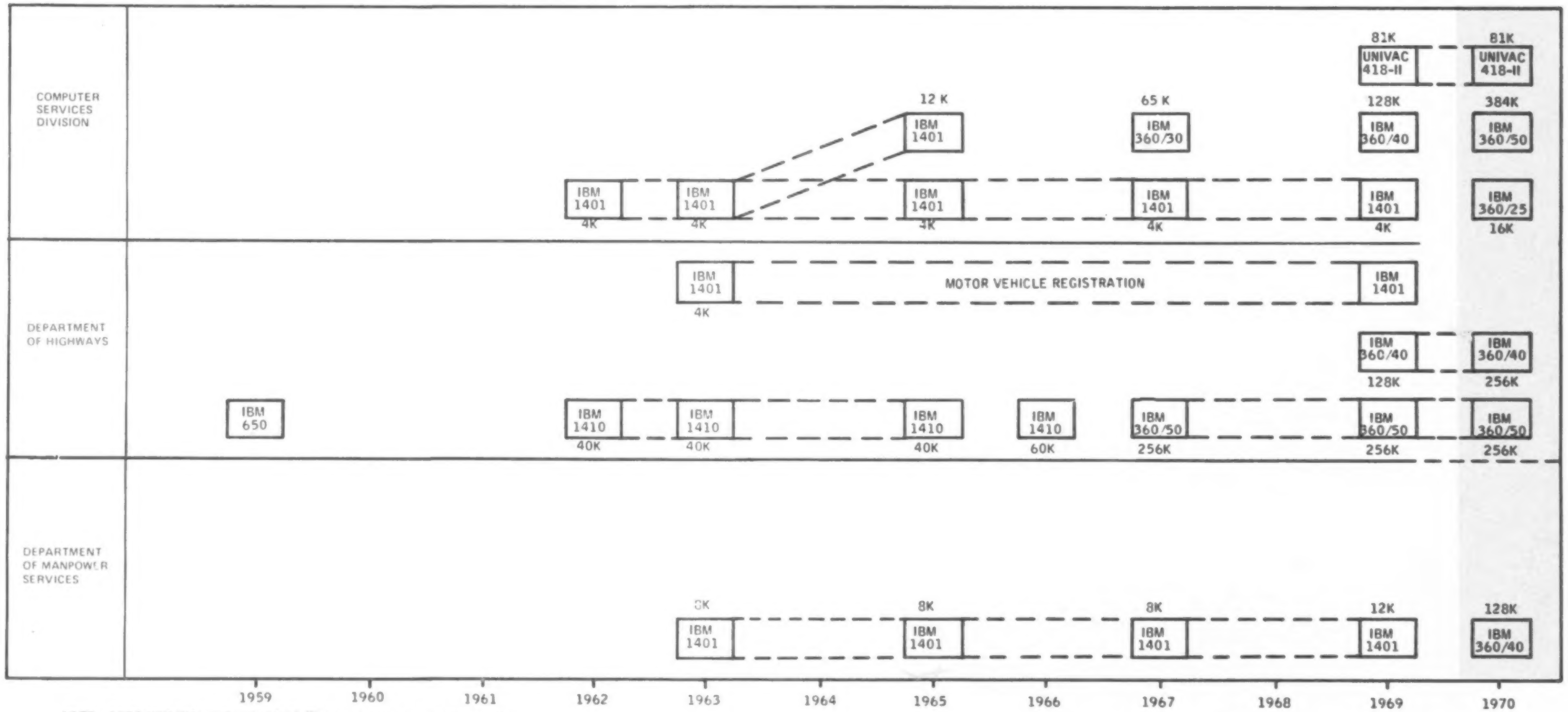
The IBM 360-40 handles the large driver license and motor vehicle applications which are based on random access files (about 2,300,000 records in each file). These files are interfaced with the UNIVAC 418-II computer which handles MINCIS (Minnesota Crime Information System). Currently, MINCIS includes message switching and data retrieval from 161 teletype machines on a state-wide network and is linked to the National Crime Information Center in Washington, D.C., and to the National Law Enforcement Teletype Systems (NLETS) centered in Phoenix, Arizona. The IBM 360-50 at the Highway Building installation can serve as back-up to the 360-40 if needed.

The Manpower Services computer activities, presently based on a second generation computer (IBM 1401), will be converted in the near future to a third generation computer (IBM 360-40). Three major applications are scheduled for implementation on the new computer in addition to the applications already existing. All three of the new applications have been or are being developed centrally by the Federal government for implementation in all states.

OPERATING PHILOSOPHIES

The Computer Services Division (CSD) is heavily involved in on-line input and updating of on-line files available for data retrieval. CSD is committed to centralization of the central processing units, to multi-programming, to operations controlled by the most advanced operating systems, to remote terminals when approximate for on-line entry and on-line retrieval, to whatever variety of data collection and input methods will attain the most efficient results, and to integration of information systems and the standardization implicit therein.

These are extremely significant decisions that have far-reaching implications for the administration of the business of the State. For example, some of the major systems involve entry of data via CRT (Cathode Ray Tube) terminals directly into the computer files, updating information already in the files via CRT terminals, and retrieval of data via CRT terminal inquiry directly from the computer data files. CSD is developing its plans on the assumption that economics and operating improvements will


COMPUTER SERVICES DIVISION
DEPARTMENT OF HIGHWAYS
DEPARTMENT OF MANPOWER SERVICES
81K
UNIVAC 418-II
81K
UNIVAC 418-II
12 K
IBM 1401
65 K
IBM 360/30
128K
IBM 360/40
384K
IBM 360/50
IBM 1401
4K
IBM 1401
4K
IBM 1401
4K
IBM 1401
4K
IBM 1401
4K
IBM 360/25
16K
IBM 1401
4K
MOTOR VEHICLE REGISTRATION
IBM 1401
IBM 360/40
128K
IBM 360/40
256K
IBM 650
IBM 1410
40K
IBM 1410
40K
IBM 1410
40K
IBM 1410
60K
IBM 360/50
256K
IBM 360/50
256K
IBM 360/50
256K
8K
IBM 1401
8K
IBM 1401
8K
IBM 1401
12K
IBM 1401
128K
IBM 360/40
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970

NOTE: DOES NOT INCLUDE HIGHER EDUCATION COMPUTER EQUIPMENT

Figure 2.1. Minnesota State Government Computer Configurations, 1959-1970

eventually require virtually all State applications and their associated files to be computer- based and available on-line.

APPLICATIONS

Applications handled by the Computer Services Division computers include a great variety ranging widely in complexity and computer requirements. Four major on-line systems provide inquiry capability into large files — the driver license and motor vehicle applications, MINCIS, and income tax. Heavy use is made of CRT input equipment for on-line entry and update and for data retrieval.

Additional major applications include sales tax, withholding tax, corporate income tax, institutional billing, and central payroll for all state employees. A massive amount of work is being handled for many engineering applications for the Department of Highways. Other applications include the accounting functions for Departments of Administration and Education, Minnesota State Retirement Association and Teachers Retirement Association receipt and disbursement processing, Division of Vocational Rehabilitation client information, Department of Education teacher personnel, and vital statistics for the Department of Health. These are but a few of over three hundred applications now in production on the State's computer systems.

Applications now under development include expansion of the MINCIS system to a large criminal justice name file with inquiry capabilities, a pupil information system for Education, insurance verification and workmen's compensation case control for Labor and Industry, land information system, revision of the sales tax system, and many others. Enormous pressures will be placed on CSD and on the users in implementing pending applications. The crucial activity is the effort required in systems design to assure a highly productive end result — an effort that must be jointly accomplished by the user and CSD. Beyond that, the programming and testing schedules must be realistically set. Perhaps most often underestimated, the conversion of data and implementation completion must be carefully planned and soundly financed. Finally, there must be resistance to the plea for expediency in violation of long range plans and priorities.

The extensive systems design, programming, and operating experience gained to date by State personnel in teleprocessing, on-line entry and update, and "real-time" retrieval of data — in short, in the most sophisticated kinds of computer applications — will materially aid CSD in moving ahead with the extensive backlog now facing it.

MANAGEMENT EFFECTIVENESS

Obtaining the greatest value for dollars expended in systems analysis and computerization is one of the toughest challenges facing management, both public and private. There are many factors which must be carefully managed, all of which are interrelated. Principal among them, however, are the quality of systems analysis and design; personnel performance in systems, programming, and operations; and type and utilization of equipment.

Systems Design Concepts

Understandably, the introduction and almost unbelievable acceptance and expansion of the use of computers in government and industry was accompanied by a pre-occupation with the computer equipment. Here was a new tool of incredible power and potential. With each passing year — in fact, with each passing month — greater speeds, increased capabilities, broader horizons appeared, and much was accomplished.

Gradually, however, as the novelty wore thin, as performance failed to meet expectations, and as complexities compounded, re-appraisals of computerization became increasingly common. Clearly, computer equipment was not at the root of the problem. More and more, attention was focused on objectives of computerization. In simplest terms and for many different reasons, most failures, and there were many, lay in the broad area of systems design.

Existing manual, bookkeeping machine, and tabulating machine applications were often simply "put on" the computer. Little if any attention was given to the computer abilities that could radically change and economize operations or to the informational needs that could be served. Certainly in the early days virtually no thought was given to integration of existing systems. Even when identified, however, this fundamental problem of poor systems design has generally not been quickly resolved. There are three reasons for this which must be well understood if appropriate planning for systems analysis and computerization is to be accomplished and then successfully implemented in Minnesota.

Organizing the Systems Function

The first of these is the organization of the systems function. The systems approach must be based upon the definition of broad objectives which are to be accomplished by the function to be systematized. It then proceeds to the detailed specification of *all activities* essential to accomplishing the function. This detailed effort must involve *all administrative activity* (not only computerizable activity), including organization structure, plans, policies, procedures, and methods. Unfortunately, and this has often been true in the State's efforts, many so-called systems efforts have been in fact "computer methods" oriented. Unless the overall systems approach is taken and unless responsibility for all systems analysis is centered in one organization, cost/benefit relationships can never be optimized.

Nature of Systems Design

The second reason is the nature of systems design. It is extremely difficult work. To be effective, it must consider *all* facets of the system. An administrative system of any size is highly complex. Any one process in a system may appear to be simple. As it is related to other processes and as it is organized in such a way as to produce the data necessary for management control and planning purposes, complications begin to arise. As each of the necessary processes is viewed in its complete detail, as all processes are interrelated, and as all management needs are provided for, the complexity further increases. Another way to say this is that the management of any activity is complex; the systems necessary to assist with that activity are also complex. It is this very complexity and the often resultant failure or inability to design a comprehensive system that has lead repeatedly to disappointing results.

Management Responsibility

The third reason for inadequate performance is failure of management personnel, top through middle, to become concerned with systems. Since comprehensive systems design vitally affects their responsibilities, managers must be deeply and directly involved. The professional systems analyst and the computer expert can be most helpful in many ways, but they cannot possibly produce a satisfactory product if management abdicates its responsibility for specifying systems requirements. The management directive to "put it on the computer" can never be a successful substitute for the rigorous management effort necessary (a) to establish the systems requirements – that is, to specify the "it", and (b) to clarify what the computer must produce.

Personnel

As computer hardware costs go down, computer personnel costs are rising. In the late fifties, computer hardware costs typically approximated two dollars out of every three spent for computerization. Now a typical installation with *all costs accounted for* will show one dollar spent on computer equipment out of every three spent on computerization. The trend is still continuing. How long it will continue depends on many factors.

The important point here is that computer personnel costs are the most significant cost in computerization. Obtaining maximum benefit from that resource will pay off accordingly. Loss of an experienced systems analyst or programmer typically represents a cost far beyond the retraining and orientation costs of most other professional personnel. This is because of the detailed knowledge of a system or systems that has been absorbed over a period of intensive study. The problem has been complicated in recent years by the great demand for systems and programming personnel with resultant rapid turnover and constant training of new personnel. Recently because of the economic condition of the country and perhaps because of some basic factors at work in the computer industry, turnover of such personnel has dropped. It is too early to detect with any certainty what future demand will be.

In any event, there is a very large payoff in controlling turnover. Continuing technical training, making available other avenues for professional improvement, the opportunity for application of knowledge, sound controls over progress on projects, informed evaluation of individual performance, and carefully planned promotion and financial rewards are all vital in this effort.

Equipment

Efficiency of the computer equipment and its operation is affected by many factors. Important among them are:

- Internal speed and memory size of the computer
- Multi-programming capability
- Utilization level
- Scheduling sophistication
- Peripheral equipment availability
- Productive vs. non-productive use.

Because of the importance of this subject and because of the interest that has been expressed in it by legislators and by top state management, a brief review is included here. This discussion is centered on the central processing unit (CPU) of the computer.

Internal Speed and Memory Size

Computer throughput — that is, unit output — increases substantially as the internal speed and memory size of the computer increases. Over the fifteen years since introduction of the first significant commercial computer, throughput per dollar of computer cost has increased radically — with estimates varying from 20 to 50 times. The precise measure of increase depends upon many factors; the important point is that computer hardware costs per unit of output have been on a consistent downward trend — a trend that is still continuing.

Multi-Programming

A second factor which takes on increasing importance as larger computers are used is the extent to which the computer is being operated under multi-programming. "Multi-programming" is a term which means the ability of a computer to accomplish more than one task at the same time. For example, part of the CPU (Central Processing Unit) and part of the peripheral equipment may be accomplishing one task, another part of the CPU and other equipment is doing something else under control of another program, while a third part of this same CPU is handling a communications system. The efficiency of multi-programming is heavily influenced by the sophistication of the operating system (a program) which "manages" the internal actions of the computer.

Utilization

Another related factor is utilization of the computer. Computer rental charges are (a) based on a one shift (176 hour) monthly usage plus a small additional charge for overtime use or (b) established at a figure which includes unlimited use. In either case, the more intensively the computer is used, the less is the cost per unit of output. The measurement of utilization is itself difficult; interpretation of the results of the measurement must be carefully done to avoid erroneous conclusions. There are three measures that may be used to indicate utilization.

7

- "Clock-time" which indicates the number of actual hours that the computer central processor is operating — that is, turned on and executing, or waiting to execute, a program.
- "Billable time" which indicates the number of "clock time" hours that the computer has worked for the customers. Under multi-programming, "billable time" may exceed the number of clock hours.
- "Meter time" which indicates the number of hours during which the central processing unit was actually executing programs.

Scheduling Sophistication

The mix of programs run at any time under multi-programming is important because of the potential conflict over peripheral units such as printers, random access devices, card readers, etc. To the extent possible in meeting deadlines, scheduling should minimize the conflicts (and the resulting waiting periods) so as to maximize output. In the dynamic environment that typifies most large computer operations and certainly is found in CSD, the scheduling task is complex and is extremely important in maximizing output.

Peripheral Equipment Availability

The proper mix of peripheral equipment is yet another important factor in attaining hardware efficiency. It is particularly difficult to establish optimally because of the changing mix of programs. Often this decision is not so critical as decisions on other factors since the unit cost of such equipment is relatively low.

Productive vs. Non-Productive Use

A further factor in measuring computer efficiency is the amount of make-ready time; unscheduled downtime for maintenance; and re-run time, the latter caused by program error, operator error, erroneous data, or computer malfunction. These are considered non-productive time. (The question of the efficiency of the use of productive time is important but is related mainly to the quality of systems design and programming.) How much productive use is obtained from a set time period may be measured by billable time minus non-productive time.

In any event, an authoritative measure of the efficiency of the computer equipment and its use can be determined only with a full knowledge of the computer configuration, operating systems, scheduling requirements, and detailed records of productive and non-productive time.

Minnesota Computer Utilization

The State of Minnesota central computers have generally experienced high utilization in recent years. Utilization at the Centennial installation has been extremely high, occasionally so great as to affect customer service adversely because of schedule slippages due to overloaded systems. Funds were simply not available to add necessary computer capacity. Utilization of the IBM 360-50 at the Highway installation has been reduced since the 360-40 was installed to handle the drivers license and motor vehicle systems. Therefore, capacity exists for the first time in recent years to absorb increasing workload without stress on existing applications. This situation, however, is only temporary.

Table 2.1 shows both the "meter time" and the "billable time" for the two principal computers. "Billable time" is the total hours billed to users and is obtained from computer-generated data showing the elapsed clock time charged to each job. The figures on the chart exceed the number of hours in the month, indicating that multi-programming is occurring. Note that the IBM 360-40 at MHD and the UNIVAC 418-II at CSD both are scheduled to run continuously, except for preventive maintenance, 720 hours a month. They are both handling on-line, real-time systems that must be available at all times. The 360-50 at the Centennial Building is also scheduled to run 24 hours a day, seven days a week.

In February 1970, a 360-25 replaced a 1401 computer at the Centennial installation. Its use

Table 2.1. State Government Average Monthly Computer Utilization by Calendar Quarter

	IBM 360/40 (256K)		IBM 360/50 (256K)	
	Meter Hrs.	Billable Hrs.	Meter Hrs.	Billable Hrs.
Third Quarter 1968	382.97	596.94	423.75	828.17
Fourth Quarter 1968	460.66	729.62	389.76	823.10
First Quarter 1969	524.07	917.22	442.24	886.08
Second Quarter 1969	587.65	1,637.03	458.78	1,208.40
Third Quarter 1969	575.90	1,402.99	468.84	559.68
Fourth Quarter 1969	569.64	1,399.65	436.13	609.14
First Quarter 1970	461.42*	1,117.62	583.41	1,040.21
Second Quarter 1970	586.04*	1,597.86	497.47	599.93

*Model 40 was upgraded in February 1970 to a Model 50 (384K).

has increased from 209 billable hours in February to 358 in July. Many presently operational systems on the IBM 360-25 are processed under an "emulation" mode. This mode is generally considered less than efficient. Much progress is presently being made in the redesign and reprogramming of these applications for more efficient third generation programming systems. As this work continues, it will slow the rate of computer utilization increase because of greater efficiency.

Computer utilization in the Department of Manpower Services has not kept pace with that in the Centennial and Highway installations. Although precise figures were not available, use of the 1401 system during the past two years has been running between one and two shifts or 176 to 350 hours per month. This rate will fall still lower with the installation of a substantially larger computer in the near future and is expected to remain at a relatively low level for at least a year.

Total utilization of the State computers will gradually increase as additional applications are added. Because of the scheduling flexibilities inherent in the rather substantial base of computer power, the utilization growth can be well planned and controlled. Additional capacity can be added when necessary in a manner consistent with overall plans. The recent reorganization of systems and computer responsibilities enhances the State's ability to attain more efficiency in computer use. Maximum efficiency, however, will be possible only when the central computers are in a common location. It is important to note also that full compatibility between the systems is necessary to attain highest utilization. This means, for example, that the two 360-50 computers should be operated under the same operating system, that programming conventions must be identical, that teleprocessing and graphics network and interface control programs must be standardized. These conditions do not now exist.

The question is often asked: What is good utilization of computer equipment? This question, as indicated at considerable length earlier, is extremely difficult to answer. Various figures have been suggested as saturation points, ranging from as low as 60 percent to usually not over 85 percent. But the figures are generally meaningless because of the lack of a generally accepted definition of utilization. The one thing that can be said authoritatively is that a grouping of computers provides the possibility for higher utilization for reasons discussed earlier. If for example, an acceptable, carefully defined utilization rate for the computer in an installation with one computer is set at 70 percent, such a rate for the same computer in a computer installation with several computers could be safely set much higher – perhaps as high as 90 percent. This is true because of the flexibility of a group of centralized computers to handle peak loads and unusual problems, whereas the single computer must plan for the indeterminate impact of unusual problems as well as the effect of unavoidable peaks.

COMPUTERIZATION COSTS, WORKLOAD, AND FUNDING PROJECTIONS

Past Expenditures

Table 2.2 shows the readily ascertainable cost of systems and computerization in Minnesota for the fiscal years 1966 through 1970. These figures reflect costs for personnel, equipment, and related factors, for the most part, in the Computer Services Division, Department of Highways, and Department of Manpower Services, but also include such costs for other agencies of government, exclusive of higher education. They do not, however, reflect the cost of non-computer systems personnel, data input preparation done by a user agency, or the input and output control costs incurred by those using computer services. Nor do they include the significant costs of space and power since the State does not presently charge the computer operations for either.

It is emphasized that whereas the costs within the three main computer operations have been well accounted for and clearly reported, the total costs to the State of processing many applications are not known. To carry out requirements of sound feasibility analysis and subsequent evaluation of applications, such costs must be accumulated. These requirements are being considered in the development of a new State accounting system, currently underway.

Trends Which Will Affect Future Requirements

Pressure for increasing State budgets for computerization is going to continue in the forseeable future as a result of a number of factors. Important among these are:

- Basic economics of computerization vs. manual processing methods. Total costs per unit of computerized output and files are going down whereas sharp cost increases characterize manual procedures and manually maintained files. Computer applications, both operational and informational, formerly marginal, will become economically feasible.
- Increase in the volume of transactions in existing applications, resulting from population growth, affluence, or public policy.
- Increasing experience with and understanding of information systems and other computer capabilities by user management personnel.

Table 2.2. Total Costs – Minnesota Systems and Computer Operations

Fiscal Year	1966	1967	1968	1969	1970
Total Costs	$1,999,000	$2,221,000	$2,934,000	$3,856,000	$5,105,000

- Probable new social service programs, both Federal and State.
- Increasing requirements for data byFederal agencies.
- Increasing sophistication in systems design resulting in part from continuing technological developments (as in telecommunications and microfilming) and in part from greater strength and experience in systems personnel.
- Increase in the State's servicing of local government through computerization; MINCIS and its further development is an example.
- More rapidity and lower cost of implementing new systems because of progressively more efficient programming, more experienced programmers, and the expected use of programs developed in other jurisdictions.

A number of these factors, while contributing to the total effect of upward budget pressure for computerization, will at the same time be placing a significant downward pressure on total State costs. This will occur both through direct and indirect cost/benefit.

Potential Budget Levels

All projections of future budgets for information systems are compounded not only by the factors mentioned just previously but by many other factors such as the extent and rate of inflation, the State salary plan, impact of technological change, and the legislative decision as to control over systems analysis and computerization. In this connection, it must be again emphasized that the historical costs are not all-inclusive since it was not possible in the course of this study to obtain comprehensive cost data. The historical costs are understated, probably substantially. To the extent that future projections are based on those costs, they will likewise be understated. It is also emphasized that these are only suggestions. They may be materially different from actual requirements both because of timing changes or any of the many factors mentioned previously.

Four factors were evaluated in developing potential budget levels for the next five years:

- The number of major applications.
- Expenditure trends in recent years.
- Information systems expenditure as a percent of total State expenditures.
- Computer hardware cost comparison with other states.

The results of these evaluations are outlined below.

Major Applications

A "major application" defined in a broad sense is a function performed by the computer system for a unit, division, or department. It may consist of one or many programs. For example, in an application called Forestry Time Summary (to obtain Federal reimbursement on work performed by Conservation employees in state forests), three programs are required to summarize hours spent on specific tasks. Another example of a major application is the processing of the State payroll. This application is composed of more than 60 linked programs.

In June, 1970, the inventory of existing major applications for all State agencies was 332. There were then 45 additional major applications in stages of systems design, programming, or implementation. During the course of this study, 174 new major applications were identified. Some of these are major enhancements to present systems, and others will require development of new systems and programs. Some will be found to be impractical candidates for computerization because of unfavorable cost/benefit analyses. For purposes of this analysis, it is estimated that 140 (80 percent) of these applications will ultimately be implemented in one form or another.

It is further estimated that 125 additional major applications will be identified and implemented in the next five years, 75 by the 16 agencies in the study and 50 by all other agencies of the State.

This represents a total of 265 new major applications. Generally, the new applications — both because of their nature and because of the present level of sophistication of the State's information systems effort — will be far more complex than those currently implemented. It is conservatively estimated that these new applications will require on the average twice the developmental, operating, and maintenance cost of the existing applications. Applying this factor to the 265 major new applications gives a 530 equivalent figure to add to the existing 332 for a total 1975 count of 862. It is estimated, however, that 100 of the existing applications (30 percent) will be eliminated by obsolescence or by revisions so major as to be included in the new applications.

This, then, would produce by 1975 the data shown in Table 2.3.

Figure 2.2 shows the above workload projection data in graphic form. Line A represents the anticipated decrease of 100 applications over a five-year period based on the elimination of some of the 332 applications existing in 1970. Line B shows the effect of the 140 new applications which have been identified in this study. Line C is the additional workload expected from the 125 additional new, but as yet unidentified, applications in the 1971-1975 period. The trends shown in Lines B and C provide for the increased complexity of future applications by applying a factor of two as described above. Lines A, B, and C are cumulative; Line C, therefore, represents, on a 'straight line' basis, the total projection of applications workload.

The translation of this straight line relationship into annual costs required for implementation will not result in a linear cost relationship. The rate of growth and associated costs of an information processing organization are determined by its ability to expand at a reasonable rate, the priorities given to implementation of various applications, limitations imposed by funding, and many other factors mentioned earlier. The overall trend, however, is clear. The workload in State computer operations will increase by at least 130 percent over the 1970 level in the next five years.

Trends in Information Systems Expenditures

The State's five-year information system expenditure history and the annual rates of increase are shown in Table 2.4. The high rates of increase in 1968, 1969, and 1970 reflect in part the effort begun in 1968 to accelerate the development of information systems. As discussed in detail elsewhere in this report, substantial progress has been made in many areas in the three-year period; the funds have been productively applied. Growth at that rate on a continuing basis, however, may impose burdens on management that cannot be handled as effectively as has been the case up to this time.

Information Systems Cost Related to the State Budget

The substantial increase in information systems costs has occurred during a period of sharp increase in total State expenditures. The figures for the most recent five years are shown in Table

Table 2.3. State Government Estimate Major Applications by 1975

	Existing 6/70	Eliminate 7/70-6/75	Add 7/70-6/75	Equivalence Loading*	Estimated Total
Actual	332	(-100)	265	0	497
Equivalent	332	(-100)	265	265*	762

*This reflects the conservative estimate that applications added during the next five years will require on the average at least twice the developmental, operating, and maintenance cost of the existing applications.

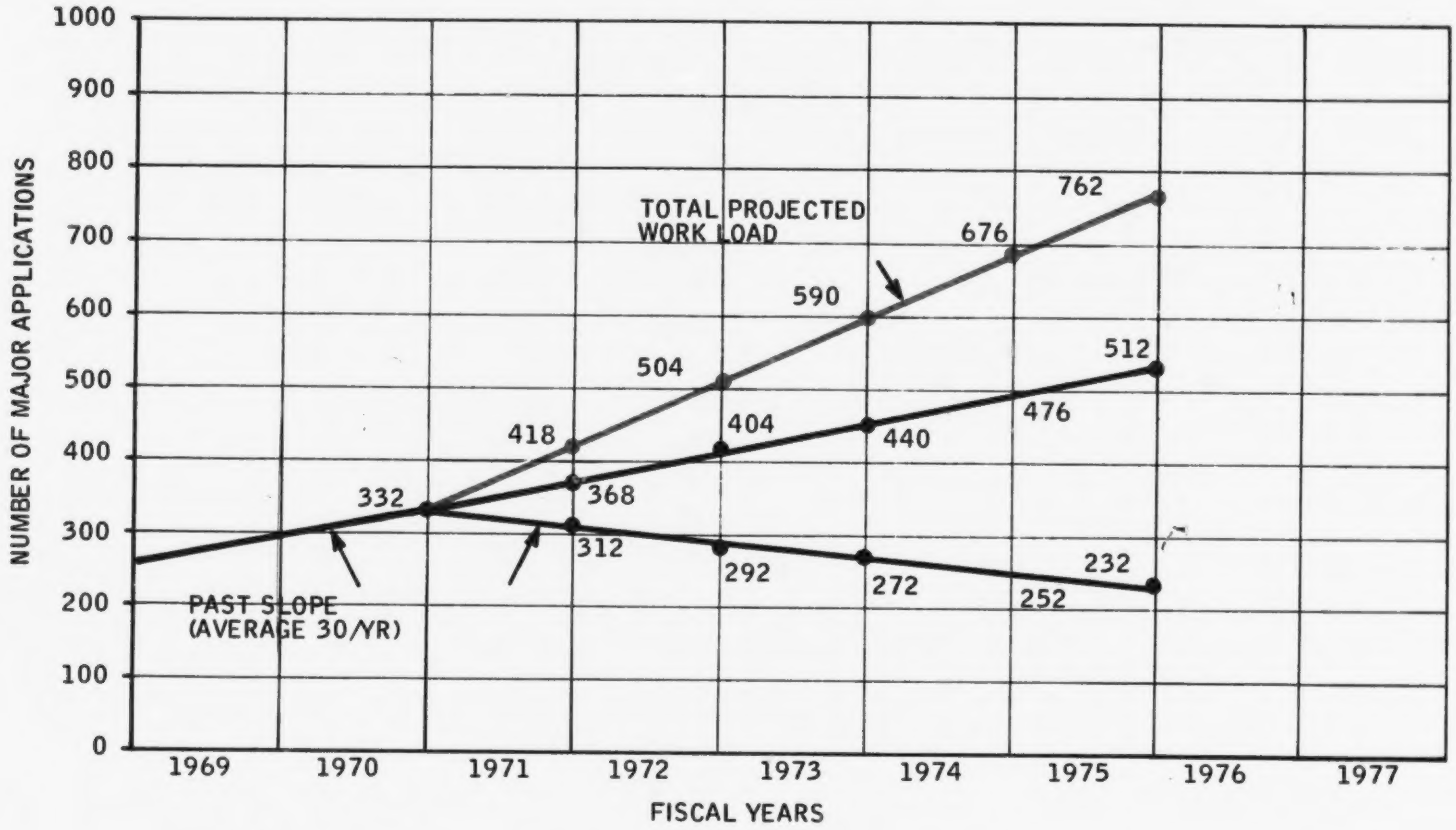


Figure 2.2. Projected Workload – State Government Computer Operations

2.4 and are accompanied by annual rates of change. The table also includes the annual percentages of total State expenditures represented by information systems expenditures. Aside from noting the trend of such figures, caution should be exercised in drawing conclusions from them. The expenditures are total and include figures not relevant to the expenses for State government computerization, such as Federal aid, State grants-in-aid to elementary and secondary education, and State appropriations to higher education. The final line in the table relates the annual rates of growth of total expenditures and information systems expenditures.

Comparison With Other States

In the course of this study, it was not feasible to obtain total costs of information systems in other states for comparison with Minnesota. However, it was possible to obtain an estimate of computer costs for comparative purposes. Figures 2.3 and 2.4 compare (1964-1969) the States of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin on two points:

- Estimated value of computer hardware per state resident.
- Estimated value of computer hardware per state employee.

Table 2.4. Total Expenditures and Annual Growth Rates for State of Minnesota Government and State Computer Operations (Dollars in Millions)

Fiscal Year	1966	1967	1968	1969	1970
Total State Expenditures	$1,088	$1,168	$1,507	$1,727*	$1,860*
Annual Rate of Increase in State Expenditures	9.2%	7.4%	29.0%	14.6%	7.7%
State Computer Operations Expenditures	$2.0	$2.2	$2.9	$3.9	$5.1
Annual Rate of Increase in Computer Operations Expenditures	–	11.0%	31.8%	34.5%	30.8%
State Computer Operations Expenditures as a Percent of Total State Expenditures	0.184%	0.190%	0.195%	0.223%	0.274%

*Estimated

Significant observations from this table as related to Minnesota are:

- In terms of computer hardware cost per resident in 1969, Minnesota was clustered with Illinois, Indiana, and Michigan in a group far below Wisconsin and Iowa and substantially higher than Ohio. In 1967, Minnesota's computer hardware cost per resident was the lowest of the selected states, moving up sharply in 1968 and 1969.
- Minnesota ranks low in computer hardware costs per state employee. In 1967 and 1968, Minnesota ranked the lowest among the selected states, but in 1969 moved ahead of Ohio and equalled Michigan.

Information this sketchy cannot be used for definitive analysis. For example, there is no tabulating equipment cost included. Further, qualitative questions are omitted such as the level of multi-programming, cost effectiveness of the systems, etc. It is clear, however, that Minnesota computer hardware expenses have been relatively low and only recently have begun to move upwards toward the average levels of the other states shown. Table 2.5 below relates to Minnesota as of June 30, 1970 and shows the estimated annual computer hardware costs both on a purchased and leased basis. The estimated total information systems costs relative to state residents and state employees are also shown.

Potential Funding Levels

As discussed above, four factors were evaluated in the development of projected budget levels applicable to State information systems requirements for the next five-year period. These are the number of major applications, anticipated expenditure trends in recent years, information systems expenditures as a percent of total State expenditures, and historical computer hardware costs in Minnesota as compared to other states. Figure 2.5 and Table 2.6 show three of these various alternatives projected in graphic and tabular form.

Curve A in Figure 2.5 reflects the "major application" analysis. It is based on the assumption that the rate of implementation of applications over the five-year period will be constant and, accordingly, that the number of applications implemented each year will increase.

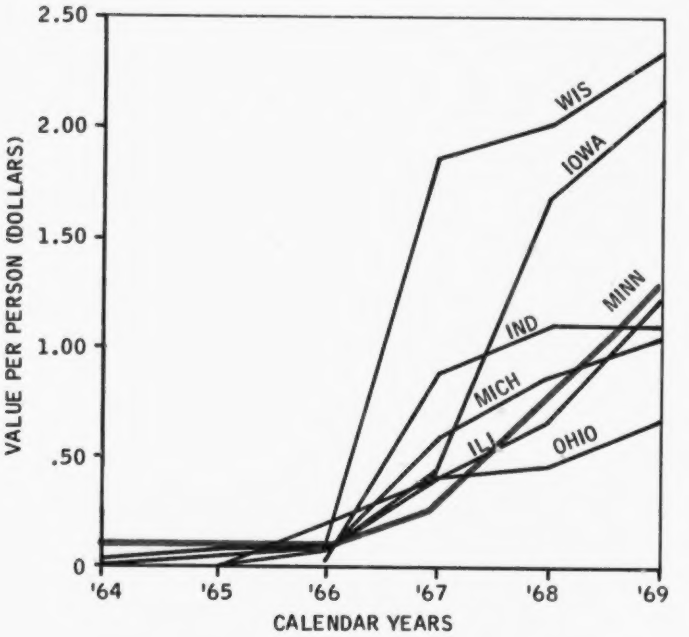


Figure 2.3. Seven State Comparison Estimated Value of Computer Hardware Per State Resident (Based on Purchase Price)

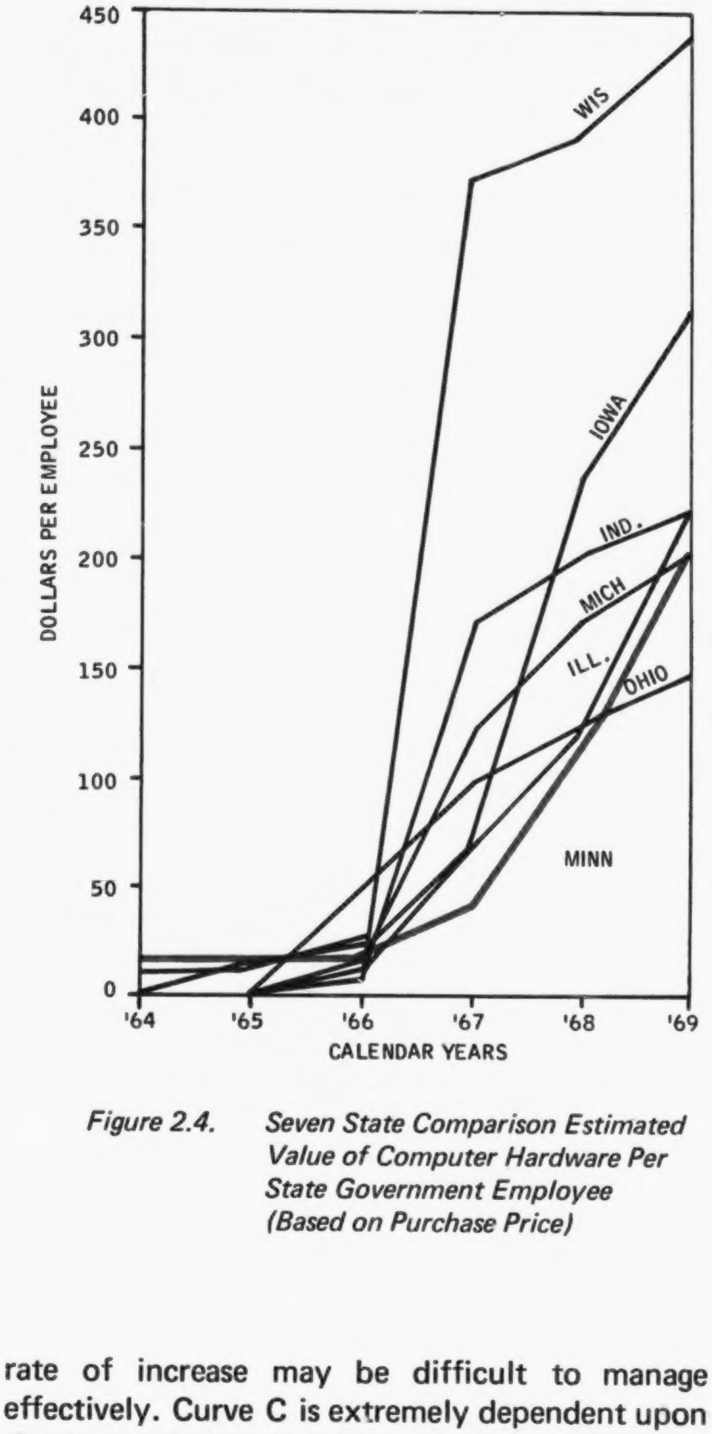


Figure 2.4. Seven State Comparison Estimated Value of Computer Hardware Per State Government Employee (Based on Purchase Price)

The total costs of operating existing systems will increase each year as will maintenance costs, at approximately the same rate as the new applications. Curve B is simply a projection on the basis of 32 percent a year, the most recent three-year average of annual rate of increase in State information systems. Curve C represents a projection based on the historical relationship between the trend in total State expenditures and the trend in State expenditures for information systems, using the projected State budget figures as the base line for the future. It assumes that the historical trends of the increasing percent of the budget going to computerization will continue and that State expenditures will grow in the future at the average rate of the past five years.

Curve A appears to represent a reasonable approach to funding for State information systems. It is based on a measure of workload. Admittedly, that measure is far from precise both in terms of number of applications and complexity. But it is a measure and one which results in a fairly manageable growth rate. Curve B is based on a "catch-up" period in State computerization and attempts no relationship to workload or to overall State growth. Further, the rate of increase may be difficult to manage effectively. Curve C is extremely dependent upon the level of the total State budget. It does not relate directly to the workload in information systems which remains regardless of the level of overall State spending.

The projection indicated by Curve A is suggested as a basis for future planning but not for legislative appropriation. The deficiencies in the present cost data; the rapidly changing nature of Federal, State, and local information requirements; developments in systems and computer technology and art; inflation;

Table 2.5. *Minnesota Estimated Costs of Computer Hardware and Information Systems Per State Resident and State Employee — 1970*

	Estimated Cost Per State Resident	Estimated Cost Per State Employee
Computer Hardware: Purchased Basis	$1.59	$240.00
Computer Hardware: Leased Basis 27% of Purchase	$0.43	$ 64.80
Total Information Systems Costs	$1.35	$207.00

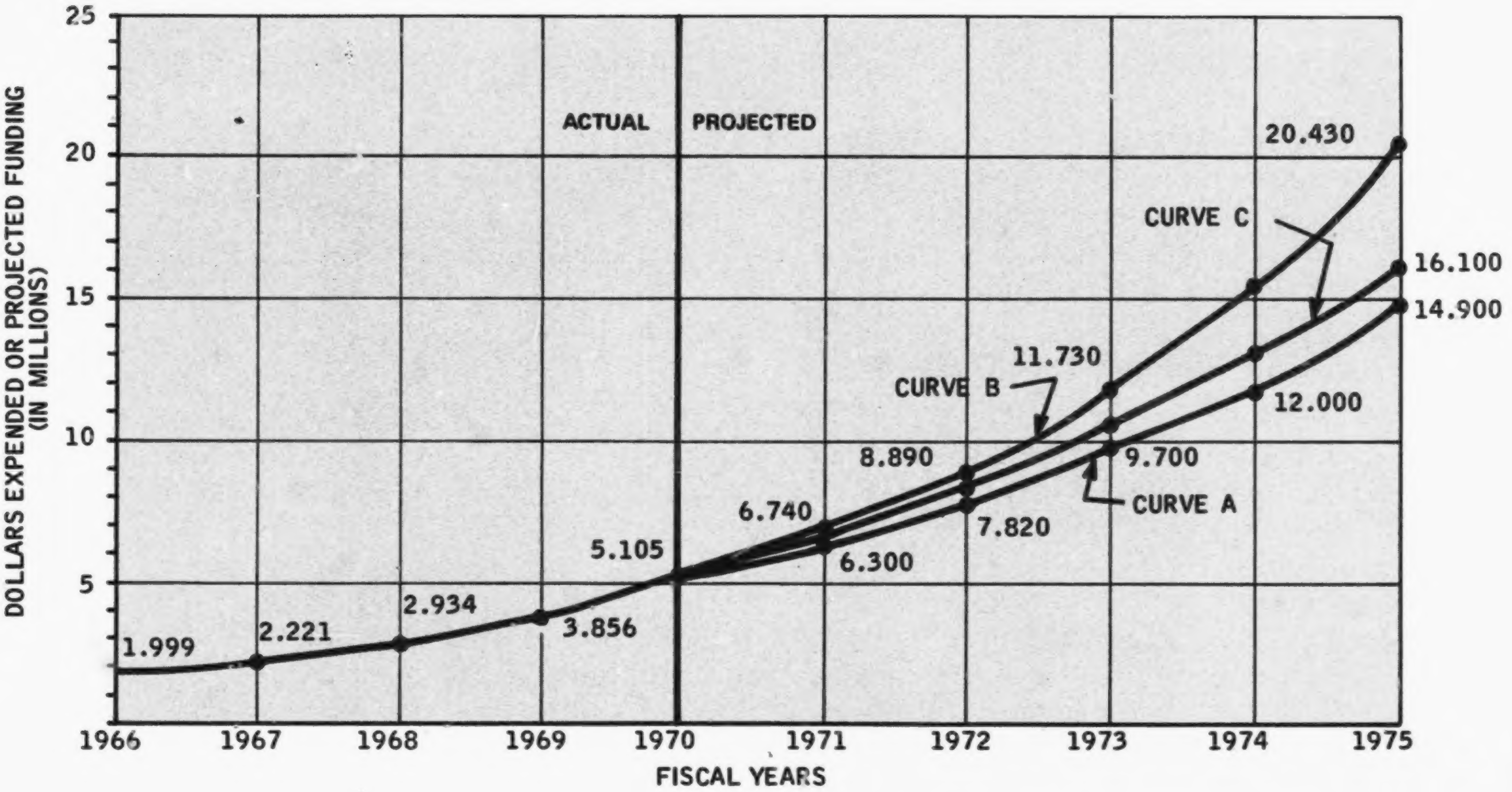


Figure 2.5. Expenditures and Projected Funding Trends — State Government Computer Operations

Table 2.6. Funding Projections for State Government Computer Operations (Dollars in Millions)

Fiscal Year	1971	1972	1973	1974	1975
Projected State Budget	$1,931*	$2,161**	$ 2,419**	$ 2,708**	$ 3,031**
Annual Increase	3.9%	11.9%	11.9%	11.9%	11.9%
Funding for the State Computer Operations Based on Major Applications Workload	$6.300	$7.820	$9.700	$12.000	$14.900
Annual Increase	23%	24%	24%	24%	23%
Funding for State Computer Operations Based on State Information Systems Annual Growth Trends	$6.740	$8.890	$11.730	$15.480	$20.430
Projected Trend of Ratio of Computer Expenditures to Total State Budget	0.326%	0.377%	0.428%	0.479%	0.530%
Funding for State Computer Operations Based on Relationship of State Information Systems Expenditures to Total State Budget	$6.300	$8.150	$10.350	$12.290	$16.100

*Estimated 1971 Budget.

**State expenditures are projected at an annual increase of 11.9%. Data available from the Statistical Abstract of the United States for 1969 indicates the national annual increase in State Government expenditures for the years 1965 through 1967 was 12.6%

availability of personnel competent to accomplish the necessary systems analysis, programming, and operational functions; and many other factors make a definitive recommendation for future appropriations not feasible. It should also be noted that implementation of certain massive projects, such as a new MEDICARE system or Federally prescribed Manpower Services Department projects, may materially increase these levels in the near future. Based on all experience to date in public and private enterprise, it is probable that the projection will be conservative and will have failed to account for growth in computerization which has almost always greatly exceeded expectations. Finally, it is postulated that Curve A would not substantially alter Minnesota's position in the next five years relative to the states referenced in this section.

Projection of the level of funding beyond five years is extremely hazardous. The only point of certainty is that computerization will become more inclusive year by year until all administrative activity is computer-based. What this means in terms of costs, however, is far too dependent on many of the uncertainties mentioned previously to permit projection on any reasonably sound basis.

3. COST/BENEFIT CONSIDERATIONS

DOES COMPUTERIZATION REALLY PAY?

The introduction to this report includes comments about the economics of systems analysis and computerization. The rationale always comes down to the need to provide benefits greater than the cost of attaining them. It appears fashionable, however, in some circles to discount the direct cost/benefit capability of systems analysis. "Computerization never saves money." "We never cut our payroll." "Everytime we put something on the computer, it costs more." These and similar remarks are frequently heard from computer personnel as well as users. Two simple answers to statements such as these are: (1) applications should not be computerized where cost effectiveness does not result, and (2) it is hard to believe that both private enterprise and government are massively embracing disciplines and techniques that cost more than their worth. More complete answers follow:

- Generally, the costs of the existing system are not known. Thus, it is often impossible to determine the cost savings of the new system.
- Often feasibility studies are not made to determine expected net cost or savings. Even when studies are made, often there is no follow-up to assure attaining the benefits.
- Frequently, systems analysis produces additional results of substantial value to management, not previously available.
- Increasing workloads are sometimes overlooked in making cost comparisons after the fact.
- In many cases, the effect of wage increases and inflation on the previous system are not properly considered in making comparisons.

It must be repeated here that neither the State's accounting system nor its past approach to systems have contributed to cost/benefit analysis. It is difficult, therefore, to demonstrate cost/benefit on a general basis. Two examples of direct cost/benefit in Minnesota are presented, an analogy is drawn from the experience of another state, and some comments made about the indirect cost/benefits of selected present and planned systems.

Income Tax Processing

The figures in Table 3.1, supplied by the Minnesota Department of Taxation, give some measure of impact of computerization on income tax processing.

Thus, during the six years shown, income tax returns increased by 29 percent while the hours worked by seasonal employees on those returns decreased by 7 percent. If the seasonal employee hours had increased proportionately to the increase in returns, 46,700 additional hours would have been required. Although precise figures are not available in full time employment, it is conservatively estimated that no more personnel are now being used than the approximately 90 assigned to these functions in 1964. The 29 percent growth factor, however, could have been expected to add about 26 full time employees to the work force since 1964. Thus, the 1969 fiscal year direct personnel cost avoidance in these activities is conservatively estimated at the annual rate of about $230,000 (46,700 seasonal employee hours at $1.90 and 26 full time employees at $5,400 per year).

A more general set of income tax cost data is presented in Table 3.2. The figures in the first two lines, supplied by the Department of Taxation, show the trend in total costs of administering all Minnesota income tax laws. The

Table 3.1. Minnesota Income Tax Processing, Seasonal Hours vs. Returns Filed (Figures in Thousands)

Fiscal Years	1964	1965	1966	1967	1968	1969
Total Hours Worked by Seasonal Employees	130	125	127	135	129	121
Annual Rate of Change	–	-3.8%	+1.6%	+6.3%	-4.4%	-6.2%
Income Tax Returns Filed	1,370	1,426	1,501	1,586	1,659	1,760
Annual Rate of Change	–	+4.1%	+5.3%	+5.7%	+4.6%	+6.7%

Table 3.2. Estimated Cost of Administering Minnesota Income Tax Laws – Fiscal Years 1964-1969

	1964	1965	1966	1967	1968	1969
Costs per $100 of Gross Collections	$1.34	$1.19	$0.93	$0.90	$1.01	$0.90
Cost per Return Filed	2.11	2.08	2.11	2.07	2.37	2.30
Cost per Return Filed Assuming No State Salary Plan Increase Since 1964	–	1.98	1.99	1.77	2.03	1.83

last line contains estimates of what the cost per return filed each year would have been if there had been no salary plan increases from 1964 through 1969. It is emphasized that the table reflects the results of all administrative action taken over the years, not only computerization.

Three additional points must be noted. First, no consideration is given in the above figures to the fact that processing requirements have become much more complex and costly over the years as a result of changes in the tax laws and research requirements. Second, the data shown above begin with 1964. Actually, the income tax computerization represents the continuation of an effort begun in the 1940's on tabulating equipment. The impact measured since 1964 is, therefore, only a part of the story. Third, no effort is made to evaluate the intangibles of service to citizens and information for management.

In summary, even on the basis of incomplete data, it is clear that direct cost/benefits have resulted from the systems analysis and computerization related to income tax processing; further, indirect benefits have been substantial.

Engineering Tasks

In a carefully documented study dated October 1966, the Minnesota Department of Highways showed substantial direct cost/benefit.[2] The annual pre-automation costs of performing certain engineering tasks were $2,748,875. After computerization, the costs were $1,129,971. The $1,618,904 saving amounted to nearly 59 percent of the original cost. It can be presumed that the annual benefit has increased materially since then because of (a) volume increases, (b) increasing sophistication of the computer applications in the analysis, and (c) the rapidly rising costs of manual operations and the relatively slower increase in computer related costs.

Another State

Claims for benefits in computerization made in another state – although not directly applicable to Minnesota — may have some relevance to Minnesota. Through its program of automation up to 1968, Pennsylvania claims to have *avoided* the cost of 20,000 employees representing $120,000,000 annually.[3] Assuming the same level of accomplishment in Minnesota, the benefit would have approximated $42,000,000 annually. Even a quarter of that figure would be well over three times the $2,934,000 spent by Minnesota State agencies on information systems in 1968.

Indirect Cost/Benefit

There are many types of indirect cost/benefits that may result from well designed, computer-based information systems. Two general types are mentioned. The MINCIS system offers indirect cost/benefits that are directly related to operations. The benefits result from the increased speed and accuracy of response to inquiries from law enforcement officials relating to motor vehicle registration, driver license status, stolen property, and persons involved with the criminal justice system. The benefits from the system, which is essentially nationwide, can be extremely significant.

As the MINCIS criminal history file is completed, it can serve another general type of indirect cost/benefit — namely, for research, planning, and management control. Two systems now in the development process provide further important examples of this type of indirect benefit. These are the new state accounting system and the state land inventory system. These systems, it should be noted, will be valuable to the Legislature as well as to the Executive Branch of the State.

For the purpose of this report, no attempt is made to put a dollar value on such benefits. It is probable, however, that the indirect cost/benefits of well-conceived State information systems will exceed direct cost/benefits many times over.

BENEFITS THROUGH CENTRALIZATION

Another area for cost/benefit analysis is in the effectiveness of the computer operation itself. Minnesota has one of the most centralized computer operations of any state in the country. This report recommends a continuation of that method of operation and completion of the existing centralization plan. A hypothetical example is presented here to illustrate the inherent cost advantages of the Minnesota approach.

Figure 4.1 and Table 4.1 in the Higher Education part of this study present relative costs and processing capacities of certain sizes or classes of computers. The data reflect Grosch's Law which states that computer power generally doubles as the square of the cost. Trebling the cost increases raw computing power nine times, etc. Computing power, however, is not directly translatable to output in an information systems environment. Output is governed much of the time by the speed and availability of input and output peripheral devices, by scheduling, and by the operating systems. The cost advantage of the larger computer is, therefore, difficult to specify short of an extremely detailed analysis.

Table 3.3 lists the processing speeds of small, medium, and large computer systems, their monthly leasing costs, and the relative costs per transaction. The IBM 360 series is shown in the illustration because CSD uses that series extensively. Using Table 3.3 as a base, an example is constructed in Table 3.4 portraying what could have happened had the State permitted the development of a whole series of separate computer centers. The example assumes that six independently operated computer centers of varying capacities would exist in Minnesota. Workloads and the annual lease and other costs are shown for each of the six centers. These costs are compared with those of one large centralized operation having the theoretical capability of performing the same data processing workload. Costs other than equipment are shown as equal to twice the equipment costs. This reflects the general rule at this point in time that such a cost relationship does in fact exist. None of the one-time start up costs for an installation is shown although they could be substantial.

Table 3.3. Estimated Computing Power as a Function of Monthly System Leasing Costs IBM 360 Series

System	Nominal Class	Typical Monthly Lease Cost	Capability (Number of Transactions Per Hour)	Relative Cost Per Transaction*	Speed Advantage Compared with:	
					360/30	360/40
360/30	Small	$ 8,000	18,000	1.0	–	–
360/40	Medium	12,000	60,000	0.45	3.3/1	–
360/50	Large	25,000	240,000	0.29	13/1	4/1

*Relative cost per transaction is not expressed in a unit of measure (such as dollars); it shows the greater efficiency of the medium and large system in relation to the small system which is used as a reference.

Table 3.4. Estimate of Equipment Rental and Other Costs for Six Separate Site Configurations vs. A Centralized Configuration

Site	Trans. Load Per Hour	Systems Used	Monthly Lease Cost	Annual Lease Cost	Annual Costs Other Than Equipment*	Total Annual Cost	Total Cap. Trans. Per Hour
#1	70,000	1 360/40 1 360/30	$ 12,000 8,000	$ 144,000 96,000	$ 288,000 192,000	$ 432,000 288,000	60,000 18,000
#2	150,000	1 360/50	25,000	300,000	600,000	900,000	240,000
#3	25,000	1 360/40	12,000	144,000	288,000	432,000	60,000
#4	10,000	1 360/30	8,000	96,000	192,000	288,000	18,000
#5	175,000	1 360/50	25,000	300,000	600,000	900,000	240,000
#6	170,000	1 360/50	25,000	300,000	600,000	900,000	240,000
Total	600,000		$115,000	$1,380,000	$2,760,000	$4,140,000	876,000
Centralized Site Configuration	600,000	3 360/50's	$ 75,000	$ 900,000	$1,800,000	$2,700,000	720,000
Annual Cost Benefit Difference				$ 480,000	$ 960,000	$1,440,000	

*Includes other expenses such as supplies, power, etc.

The costs resulting from the analysis – $4,140,000 for the separate installations and $2,700,000 for the single installation – result in a 1.52 to 1 ratio. That is, decentralization would cost about 50 percent more than centralization. If this relationship were directly transferable to the present situation in Minnesota, the $5,105,000 expended on information systems would have approximated $7,760,000. Applying the factor to the potential budget figures in the years 1971-1975 (Table 2.6), a total difference of $26,374,000 would be realized.

These figures, however, must be tempered by two main factors. The first is that Minnesota is not fully centralized. The Department of Manpower Services has not yet been organizationally integrated and has a separate computer. Second, the numerical relationships in Tables 3.3 and 3.4 cannot be assumed in actual application. Nonetheless, realization of as much as a half, a third, or a fourth of the theoretical savings would represent a substantial total. It is important to note that a number of states, including California, Florida, Pennsylvania, Washington, and others, have taken action to reduce the number of data processing installations with expectation of very substantial savings.

The case for centralization cannot be made solely on such savings. Centralization's inherent strengths must be capitalized upon and its potential administrative disadvantages guarded against if optimum results are to be obtained. A number of recommendations in Section 4 are related thereto.

4. THE MINNESOTA SYSTEMS PLAN

Throughout this report, there have been references to the rationale for the development of sound systems to aid in ordering the processes of business, industry, and government. The nature and increasing importance of computerized information and decision systems have also been discussed. It has been stressed that the crucial factors in successful accomplishment of organizational objectives are first, clear definition of those objectives and second, sound systems design.

The plan outlined in this section and designated as MIDS (an acronym for Minnesota Information and Decision Systems) aims to achieve two broad objectives:

- To make available to the Legislature and to officials of the Executive Branch comprehensive and accurate information in a form and at a time to be of maximum value in decision-making and research.
- Provide to all State personnel the most effective framework of systems, procedures, and methods within which to carry out the operations of the State.

The implications of implementing MIDS are enormous. In its broadest terms, MIDS means defining, designing, and implementing comprehensive systems for each area of government to serve as the framework for attaining optimum effectiveness of state operations. A major requirement is the ability to associate and interrelate the data bases of the information systems serving major functional areas of government. Corollary to this is the installation of procedures to assure the integrity and confidentiality of data.

IMPLEMENTATION OF MIDS

Much that Minnesota has done in recent years is consistent with the requirements of MIDS. Action is necessary, however, in five broad areas to assure the administrative environment most conducive to attaining the MIDS objectives:

- A more comprehensive systems approach to the problems of the State.
- An organization structure effective in coordinating the design of the many major systems, building efficient operational systems for all areas of State government, attaining maximum productivity from the State's systems and computerization efforts, and providing assistance to local government.
- The planned, controlled development of systems, procedures, and methods – computer-based or otherwise – to optimize the value of data bases and information obtainable therefrom for decision-making and research, and to provide the most efficient tools for State employees to carry out the activities of State government.
- The development, installation, and policing of subsystems for assuring the integrity of computer-based and all other data and to assure confidentiality of such data by limiting its accessibility only to properly authorized persons.
- A leadership position in the development and coordination of intergovernmental information systems and of intergovernmental cooperative efforts in systems analysis and computerization.

Specific recommendations for action in each of these areas follow.

A More Comprehensive Systems Approach to the Problems of State Government

The widespread failure to date of systems analysis and computerization to reach their potential, as discussed earlier in this report, resulted generally from failure to take a comprehensive systems

3-28-

approach. The State of Minnesota was no exception. Correction of this condition requires, in Minnesota's case:

- **Assignment of overall responsibility for design, coordination, and implementation of MIDS to one agency of the government** – see further discussion on organization below. The Computer Services Division, under Executive Order No. 56, has been given broad responsibility for and authority over the development of information systems and other data processing activities. This order should be interpreted, or if necessary expanded, to include similar **authority over all systems analysis** and ultimately incorporated in the state statutes by legislative action.
- **More effective execution by the top executive in each agency of State government of his responsibility for clarifying the objectives of each function of his agency and for specifically approving the general systems required to reach those objectives.** The developmental efforts of the State PPBS (planning, programming budget system) are helping to clarify objectives in many areas, but much remains to be done. In the main, however, top State executives have abdicated or delegated to a relatively low level their responsibility for specifying requirements for systems to assist them in accomplishing their objectives. A condition precedent to all future systems studies should be the signature of the top executive of the user agency on a statement of the objectives to be accomplished. The same signature should be required as approval on the general systems design prior to beginning the implementation efforts.
- **Attendance by top management personnel of all agencies of State government at intensive courses in systems analysis, information and decision systems concepts, and computer familiarization.** To be most effective, this program should be planned and coordinated by the Division of Information Systems. Ideally, it should include a mix of professional society workshops, vendor orientation courses, and state directed sessions, the latter aimed at familiarization with MIDS and with the State's present systems and computerization efforts and capabilities. Legislators and legislative staff members should be invited to participate.

An Effective Organization Structure

The relatively strong position Minnesota occupies among the states in the broad areas of systems development and computerization has resulted from organizational decisions made over a decade ago and updated more recently. These decisions were based initially on the need to control the mechanical means of processing the State's business. Later, more attention was directed toward the overall management implications of computerization as evidenced in the 1967 and 1969 special appropriations and in the 1968 and 1970 Executive Orders.

Implementation of MIDS requires that the following further organizational changes be accomplished.

- **The State information systems function should be strengthened by improved organization and by statutory centralization in that organization of authority over development and operation of information systems and computerization.**

  Information systems are, and will continue to be, increasingly important to the operation and management of the State government, a condition which must be reflected in State organization structure. The MIDS impact on information and decision systems throughout the State, its requirements for inter-departmental cooperation and coordination, its need for fully informed representation at top level meetings with the Governor, its continually growing impact on governmental operations, its requirements for legislative involvement, and its impact on the public all add up to heavy involvement at the top level of government.

Organizational improvement can be accomplished in one of two ways: by further strengthening the function within the Department of Administration or by establishing a new Department of Information Systems.

Principal reasons for retaining the function as a Division of Information Systems under the Commissioner of Administration are that (a) the information systems function is the key to the executive management of the state and therefore key to the Commissioner who is in effect the Executive Vice President of the State; (b) there is a close relationship between information systems and budgeting; (c) there are already too many agencies of government reporting to the Governor; and (d) continuity of leadership would be obtained through an assistant commissioner or director under Civil Service.

Establishing a separate Department of Information Systems would bring the advantage of having an official at the top level of State government developing information systems. He could concentrate *solely* on the extremely important task of obtaining both direct and indirect cost/benefit from information systems and other computer systems. He would be appointed by and serve at the pleasure of the Governor.

For the organizational alternative selected, the most important requirement is that the appropriate responsibilities and authority be given to the function as outlined below. The acronym DIS in this report refers to a Division of Information Systems, and its administrative officer is referred to as Director of Information Systems.

- **All systems and computer functions of the State administration should be administered or controlled by DIS.** This means highly centralized control and coordination of systems development and computerization and is consistent with the basic concepts already being implemented in Minnesota. The organization structure of DIS should build upon that of the present Computer Services Division. It is recommended that DIS be organized with the following sections.

1. **Systems and Programming.** This section should continue its present heavy responsibilities except that software research (not software development and implementation) should be assigned to the Planning and Coordination Section. The responsibilities of the Managers of Major Systems should be broadened to include specifically *all systems analysis and design* in their areas of responsibility.

2. **Planning and Coordination.** This section should continue its present responsibilities for planning, broadened as necessary to update MIDS on a continuing basis; for higher education coordination with the State; for staff development; and for data standards. Its research function should be expanded to cover all areas of DIS responsibilities including the evaluation of new technology in hardware and software.

   A unit should be established to carry out certain broad systems activities such as forms control, records management, and work measurement, and to provide certain systems specialization such as in microfilming.

   In addition, a management science function (sometimes called quantitative analysis or operations research) should be added in this section with responsibilities for (a) establishing and maintaining a comprehensive index of all State data files, whether manual or in some way mechanized; (b) advising State personnel on the best method of obtaining, analyzing, and presenting data from such files; (c) advising State personnel on scientific sampling techniques adequate to produce statistically sound analyses; (d) assisting with obtaining special reports to meet management needs quickly; (e) advising and assisting on the application of operations research techniques to State problems.

3. **Computer Operations.** This section should continue as presently organized with line responsibility for State computer centers and a staff relationship to those in higher education.

4. **Telecommunications Section.** The State communications system is increasingly involved with systems development and computerization. Accordingly, all communications functions of the State should be administered under control of this section. The section head would chair a statewide Communications Committee recommended elsewhere.

5. **Local Government Section.** The demands for computerization at the local level are discussed in detail in Part V of this report. The State must take a leadership role in assisting with coordinated development at the local level. To give appropriate emphasis and status to this function and to build the framework for greater assistance in the future, the local government activities of DIS should be organized as a separate section. As its primary responsibility, this section should serve as the staff of the Intergovernmental Commission on Information Systems recommended in Part V of this report. Initially, the section's role will be to advise local government on systems and computerization and to begin efforts toward a common data base in local government to serve local, State and Federal needs. Then the State should begin to assist in development of common systems and computer approaches to the needs of local government. If funding is provided as recommended in this report, direct assistance to local government will assume major significance.

6. **Administrative Services Section.** This section would perform for DIS the functions normally performed by similarly named units in the major departments of State government. Among those functions is that of controllership. The need for a strong controller staff is acute and should be accomplished immediately, prior to setting up DIS. The internal budgeting, accounting, and cost accounting tasks in DIS are substantial. In particular, cost accounting is complex because of the intricacies of billing computer time under multi-programming. A further important controllership function is assuring the validity of the feasibility analyses required for proposed new systems. Corollary to that is follow-up to determine the extent to which cost benefit projections are realized.

- **Expenditure Control.** Legislation should be passed to continue in DIS the authority in Executive Order No. 56 to review and approve all proposed expenditures by any agency of the State government for systems development or computerization (equipment, personnel, programs, space, systems design, consultants, service bureaus, etc.) and extension of the authority to cover all systems activity.
- **Governor's Committee.** Legislative action is recommended to formalize the present Governor's Committee on State Information Systems or a similar group to advise the Governor, the Legislature, and DIS on MIDS plans and progress and to recommend on the expenditure of developmental funds. The Committee should be organized so as to provide continuity of approach — for example, six year terms for members, with one-third appointed each two years.
- **Agency Systems Coordination.** In Minnesota, the systems coordination function, when identifiable at all, is

typically assigned to an employee at the fourth or fifth level of management. The development and implementation of management systems is a complex matter requiring the attention, coordination, and authority of top management of the user agency. Accordingly, a systems coordinator should be appointed by each major agency of State government, reporting directly to the agency head or to his chief deputy or assistant. Heavy experience in systems analysis is the primary qualification for such a position with computer experience helpful.

- **Communications Advisory Committee.** An explosion is occurring in the demand for electronic communications of all types. Proliferation of systems, leading to duplication and overlapping, will result unless coordination is effected. As a vehicle for assuring the needed coordination, it is recommended that a Communications Advisory Committee be established, chaired by the DIS Telecommunications Section head. Membership should include representation from higher education and local government; major State users such as the Department of Highways; and State computer, radio, and telephone technicians. A major concern of this committee will be data communications.

- **MIDS User's Committee.** A committee of DIS and user personnel is recommended and is discussed immediately below.

Planned, Controlled Development of MIDS

Given the responsibilities and authorities and the top level involvement outlined above, DIS should be in a position to move the State toward the MIDS objectives. But it must be emphasized once again that proper systems design and implementation and successful computer operations are exceedingly complex and difficult and require a high degree of coordination and cooperation between DIS and the user agencies.

The major ingredients required are discussed here. It should be understood that the State has already taken some action on most of these items, in some cases with good effect and in other cases with improvement still needed.

- **First and foremost is the need for DIS and its user agencies (almost the entire State government) to work together efficiently.** It is axiomatic in this field that only truly cooperative efforts are successful. Three recommendations have been made previously in this section to strengthen the users' abilities to get what they need and want. Specific additional action that should be taken includes:

1. **Establishment of a MIDS User's Committee.** A User's Committee should be established to serve as a primary communication device in the implementation of MIDS. The committee should consist of the Systems Coordinator from each of the major agencies of government, the DIS Director, and the appropriate section heads of DIS. The DIS Director should serve as chairman the first year. The Committee should elect its own chairman in the second and succeeding years. Regular monthly meetings, with a structured agenda, should be held.

   This advisory committee should make recommendations to the DIS Director on any matters relating to DIS and its users. It should be updated monthly on the status of MIDS and on any unusual developments in DIS.

2. **Agency Systems and Computer Planning.** Long range and short term plans for each agency are essential for both the agency and DIS. The agency Systems Coordinator and the DIS Major Systems Manager for that agency should jointly develop the necessary plans. It is strongly emphasized that the Systems Coordinator, as agency representative, must assume the key role in planning. The DIS Major Systems Manager can materially assist the Systems Coordinator; but the plan must reflect the agency's real needs, not the DIS view of those needs.

3. **Agency Orientation and Training.** In addition to the orientation to systems and computers recommended earlier for agency top management, formalized and continuing training programs are necessary for agency personnel at the operating level. A spectrum of subjects should be covered including systems; controls; systems conversion techniques; input alternatives; computer techniques for data storage, management, and retrieval; general computer capability; etc.

4. **Inter-agency Reporting.** Formalized methods of communication between DIS and its users should be established and rigorously administered. These should include procedures for requisitioning service, for advising on progress, and for reporting on problems. User management must be kept appraised of status so that timely remedial action may be taken if necessary.

5. **DIS Newsletter.** A large number of significant and exciting developments have occurred, are occurring, and will continue to occur in the State's systems and computer efforts. Many of these would be of interest to user agency personnel. A simple newsletter, prepared monthly, could be helpful in the continuing orientation of agency personnel to the accomplishments of DIS users and to DIS capabilities.

- **The following guidelines should be adopted for MIDS:**

  1. A systems philosophy aimed at assisting the decision-making process as contrasted with simply mechanizing or otherwise improving a production system.
  2. A systems design to permit integrated systems. This requires the development of standard identification systems for persons, organizations, physical assets, etc.; standard data definitions, and standard computer techniques for file management.
  3. Cost/benefit analysis to establish system feasibility.
  4. Computerization developed in an environment based on centralized central processing units and whatever remote terminals are necessary to serve users.
  5. Operational objectives of on-line files for real-time retrieval of information and on-line entry and update of data originating where feasible in the user agency.
  6. Attaining maximum output from both equipment and personnel.

  Planning and implementation based insofar as feasible on these guidelines are essential to arriving at the MIDS long range goals.

- **The centralization of administration and control of systems development and computerization should be completed.** Justification for this recommendation is found primarily in the cost/benefit analysis in Section 3 of this part of the study. The important point to the user is that the necessary systems assistance and computer capability must be available through DIS.

  Alternatives to this approach include: (1) a number of autonomous computer centers, (2) functional centers serving groups of functionally related departments, and (3) regional centers serving groups of departments located in the immediate vicinity of the center. Autonomous department centers, however, tend to be restrictive to departmental needs, allowing little inter-agency data interchange and leading to duplication of file update, storage, and management. Functional and regional department oriented centers tend to create bias in favor of the prime user of the center, and permit interchange of data only among the users of each center. Furthermore, these alternatives present other problems such as staff and file duplication; inadequate overall data exchange; more difficulty in setting data, control, or operating standards; equipment inefficiency; and either a lack of, or extremely expensive, back-up facilities.

Specific action necessary to complete the centralization includes:

1. **Transfer of the computer functions of the Department of Manpower Services to DIS.** Appropriate systems personnel should remain assigned to MSD, as with other major departments, to assure systems design responsive to the needs of that department. The present resistance by MSD to integration of its computer functions is typical among such departments across the country. These departments, alone among all functions of State government, view their operations as essentially Federal because of Federal financing and have a tendency to remain apart from the regular processes of State government. The rationale, however, that applies to the centralized computer approach previously adopted by Minnesota and recommended for continuance herein is equally applicable to MSD. It is important to note that the U.S. Department of Labor's Bureau of Employment Security, the federal agency involved with MSD, issued on December 15, 1969, a policy on computerization which includes the following:

   "Maximum cooperation will be given to State governments in establishing centralized ADP facilities which will provide increased efficiency for State governments and State employment security operations and which meet Federal and State manpower priorities and requirements."

2. **Developing a schedule for phasing out tabulating machine installations in favor of computerization, including provision for remote terminals where appropriate.** Tabulating procedures are relatively costly; careful systems and conversion planning must precede conversion to the computer to assure acceptable agency service.

- **Systems activities must be economically justified.** Each systems design which is recommended for implementation – whether to be on a computer or otherwise – must be analyzed, and the feasibility of implementation determined. If feasible, and if implemented, then a planned follow-up must be completed to assure that the "pay-off" was realized or to discover why not. Unless the economics are carefully identified in advance and potential areas of increased costs and decreased costs agreed to in some detail, potential savings may evaporate.

  For example, presently three of the larger computer-based systems of the state (driver license, income tax, and motor vehicle) should be analyzed to determine whether cost/benefit projections have been realized; and, if not, to determine whether the projections still can be realized. The user agencies and the State Budget Division should be involved in such analyses, along with the DIS Controller's staff.

- **Adequate physical facilities must be provided DIS.** At present the space allocated falls short of minimum requirements. The two computer installations are on opposite sides of the Capitol Mall, preventing optimum use of the computer equipment. Air conditioning facilities in the Centennial Building installation have frequently been unable to handle the load and, occasionally, have completely failed. Both computer rooms are jammed so full of equipment as to impair the efficiency of computer operating personnel. Neither room is built so that acceptable security standards can be assured. There is in both areas inadequate fireproof space for storage of magnetic historical master and transaction files. Space assigned to the Centennial Building keypunch section is extremely crowded and generally not conducive to maximum productivity.

  Space for computer professional personnel is at the crisis point. Systems analysis and programming require heavy concentration and, accordingly, call for office space with some degree of privacy. In the Centennial area, the present space is totally inadequate, with desk space assigned to four persons in each of a number of small cubicles. The general noise level, constant interruptions, inadequate file and working area, and inadequate ventilation all militate against top performance.

Stop gap measures have been adopted over the past three years but have been outdated even before completion. It is essential that appropriate space be obtained as rapidly as possible for housing the entire computer operation in one area. If this can only be done by acquisition or construction of new space, authorization should be given now to obtain interim space to bring the two computer centers together. The space must be large enough to accommodate equipment to serve the Department of Manpower Services. Professional personnel could be housed in another area temporarily if necessary during the interim period.

Recent emphasis has been placed by CSD on the security of the computer facilities, and many improvements made. Current events give great urgency to the need to strengthen security even further. (It has been noted elsewhere in this report that the Department of Administration is projecting approximately $3,000,000 as a building cost for 60,000 square feet of space for computer purposes.)

- **Personnel costs are constantly growing as a percent of the overall costs of systems development and computerization, with the result that increasing emphasis must be placed on proper management of the staff.** Personnel utilization is now far more important than computer utilization. Selection of personnel is at least as important as selection of a computer.

The Computer Services Division, in its recent reorganization, has taken a number of steps to strengthen its management of personnel, including appointing a Manager-Personnel Development with responsibilities for training and development of CSD professional personnel. Guidelines in personnel management should include:

1. Establishment and enforcement of systems design and programming standards.
2. Administering training and development programs for personnel and encouraging involvement in professional activities.
3. Setting up schedules for all systems and programming projects and continually measuring progress against the schedules.
4. Conducting periodic performance reviews including outlining programs to strengthen individual weaknesses.
5. Periodic review of classification and pay plans to assure competitive posture, with particular emphasis currently on the positions in computer operations.
6. Continuing effort to identify and implement successful systems developed elsewhere to make more productive use of personnel.
7. Use of consultants in systems analysis and programming (1) in preference to employing a specialist for one-time or sporadic requirements, (2) to avoid disrupting schedules on existing projects when a crisis project appears, or (3) to serve upon occasion as a short-run overload staff.
8. Comprehensive documentation of systems design and programming so that knowledge does not leave with a departing employee.

These guidelines in the main have been followed by CSD. The quality of results will be in direct proportion to the supervisory attention given to their enforcement.

- **Computer capabilities of the State will require expansion as the applications increase.** Centralization provides the framework within which that expansion can be done most efficiently. Recommendations related to equipment requirements are:

1. The "Model State Contract" for leasing or purchasing computer hardware should continue to be used by the State. Modifications of terms of the contract, necessary in the past,

should not be necessary in the future. The National Association for Information Systems (NASIS), an affiliate of the Council of State Governments, is revising the contract with assistance from the National Association of State Purchasing Officials and the computer industry. The contract provides the best present basis for assuring performance by vendors.

2. The requirements for compatibility must be given appropriate weight in obtaining additional or replacement equipment. There must be the capability of direct computer-to-computer communications where required. Direct programming compatibility (or in the alternative, highly efficient translators) must be available when necessary to avoid enormous reprogramming cost.

3. Communications networks should be centered on one computer with strong communications handling capabilities (until its capacity is consumed) to avoid the expense of designing, programming, and maintaining communications systems on different types of computers.

4. Appropriate back-up equipment should be available. This is particularly important for on-line systems where working files are totally computerized. It is emphasized that total back-up is expensive and that the extent of back-up necessary must be determined by careful cost/benefit analyses.

5. To attain the substantial savings available through purchasing rather than leasing, computers and related equipment should be purchased outright or under lease purchase plans when there is reasonable expectation that equipment obsolescence will not occur prior to the breakeven point. The State appears to be in a good position to take advantage of savings through purchase because of the size of its computer requirements and particularly as it increases its assistance with computerization of local government. Equipment obsolete in one installation might adequately serve a need in another installation. If there is any question about the legality of the State's sub-leasing to local government, enabling legislation should be obtained.

6. Peripheral equipment from other than the vendor of the central processing unit should be obtained where cost effective. Substantial savings are possible, but careful planning and complete vendor understanding is necessary to assure proper maintenance support.

7. Computer utilization records should be kept on all equipment and should reflect each of the methods of measuring utilization. Continuing effort should be made to increase the effectiveness of utilization. Note, however, that interest in attaining extremely high utilization rates must not be permitted to endanger customer service or to affect adversely either the flexibility or support afforded by the computer hardware to systems analysts and programmers. No specific utilization rate is recommended as a guideline. Rather, the State should plan its computer expansion so as to maintain its generally high levels of utilization of recent years.

8. Special emphasis should be placed on evaluation of methods and equipment for input preparation because of its large potential for cost reduction.

- **A number of further actions are necessary in the implementation of MIDS.** The major points that have not been covered earlier are:

1. **Data Dictionary and Standardization of Data Elements.** In the recent reorganization, CSD set up the new position of Manager-Standards and Quality with the major objective of establishing a data dictionary and,

corollary thereto, standardizing the structure of data elements and identifiers. Because there is probably no single function more important to the long-range objectives of MIDS, this program must be given top priority and top level support. Further explanation is appropriate here, using as an example, an organization doing business in Minnesota. A typical business is "doing business" with the State in many ways: for example, withholding State income taxes from employees and remitting the amount withheld to the State; collecting sales taxes for the State and remitting them; obtaining economic data from one or more State departments; paying a State corporate income tax; paying State unemployment compensation taxes; reporting accidents to the Workmen's Compensation Commission; registering motor vehicles with the State; selling merchandise to the State; and many more depending upon the type of business. The ability of the State to service all of these activities promptly and efficiently with a minimum of duplication is important not only to the State itself but also to the business. An integrated systems approach to any business's business with the State should have a positive effect on the business climate. Among other things, such an approach requires the use of a unique, identifying code for each business entity.

2. **Controls.** No principle in computerization is so basic as the need for controls. GIGO (garbage in – garbage out) has scuttled more computer installations and damaged more user relations than all other problems. It is essential that adequate controls be established; continued failure or unwillingness by any user agency to provide control information or by DIS to establish and administer accuracy controls is a matter for prompt discussion at the Commissioner level.

3. **Standards for Systems Analysis and Programming.** A major determinant of quality production in an information systems organization is the development and implementation of standards to be followed by systems analysis and programming personnel. These standards should cover all elements of work performed by such employees – for example, documentation of existing systems, feasibility analyses, programming conventions, and program documentation. Although the State is well along with this program, it is emphasized that the enforcement of the standards must be a primary function of management in the Systems and Programming Division.

4. **Unified Operational Environment.** Probably the outstanding technical achievement of the State's computer effort was the unusual speed and success in converting both centers to full operating systems. This was an enormous task. Remaining, however, are a large number of second generation programs. Such programs which are handling important, sizable systems should be third generation programs. But straight conversion may not be the answer in some cases. Rather, the system may be in need of redesign for any one of a number of reasons. In addition, some of the programs are so infrequently used that reprogramming would not be cost effective.

   The unified operation also requires adoption of a single set of programming conventions, similarity of operating systems, and standardization of teleprocessing and graphics network and interface control programs. Unless this is done, the cost/benefit of centralization will fall far below its potential.

5. **Customer Billing.** Two billing systems are presently in use as a result of the unification of the separate operations. Development of a new billing system

should be given high priority as a major aid to the DIS internal management information system and as an aid in user relations. The new system must, of course, be consistent with both the new State accounting system and the State program budget requirements.

- **Adequate financing is essential.** With the exception of the 1967 and 1969 special appropriations, computerization in Minnesota has been financed by direct appropriation to the user agencies. As services were billed by CSD, the user agencies transferred funds to the CSD revolving account. This procedure was followed both for existing applications and those under development.

  The two special appropriations made sums available to accelerate development of new systems or otherwise advance the computer effort of the State. In 1969, however, unlike 1967, certain of the new applications recommended for development were eliminated from departmental budgets, with the understanding that funds from the special appropriation could be used for those purposes.

  It is recommended that future funding for all new systems development follow the precedent set in the 1969 special appropriation. That is, all funds for proposed new applications or resystematizing of major existing applications should be included in a special appropriation to DIS. Assuming the continuance of the Governor's Committee on State Information Systems, that committee should advise the DIS Commissioner on the expenditure of those funds. It is also recommended that an amount in addition to that necessary to fund the known new applications be included in the special appropriation for "crisis" applications or applications where the time table should be accelerated. A possible level of funding for MIDS is discussed in Section 2 of this report.

  In addition, two further funding recommendations, made elsewhere in the report, are repeated here. The first is for providing adequate space for DIS (approximately $3,000,000). The second is a special appropriation in the amount of $1,900,000 for the next biennium to assist with local government systems and computerization efforts. The second recommendation, discussed in more detail in the local government part of the report, calls for expenditure authority in the DIS Commissioner upon recommendation by the Intergovernmental Commission on Information Systems.

  Finally, in anticipation of implementing the earlier recommendation concerning purchase rather than lease, the computer revolving fund should be increased. The original working capital was set at $250,000. An additional $250,000 although inadequate for outright purchase of a sizable system, would give DIS the flexibility to purchase some equipment to effect savings.

- **Performance evaluation is desirable for all functions, but it is mandatory for DIS because of the growing impact it has on State government functions and decisions.** The evaluation should be comprehensive, including all DIS activities and those user responsibilities that affect DIS performance. This includes but is not limited to a review and analysis of budgeted vs. actual cost by project; actual system vs. the originally planned system; controls over the systems input and output and run-to-run controls to assure validity of the files; cost/benefit actually realized vs. those projected in the feasibility report. An evaluation is already being performed to a limited extent by the State Public Examiner's Office and should continue to be the responsibility of that office. The function requires a high level computer professional with both substantial management experience and a heavy accounting background.

Integrity and Confidentiality of Data

The guidelines just discussed included recommendations for establishing and administering proper controls. In this recommendation, attention is focused on the need for assuring integrity of data files by preventing willful tampering with data and by providing detailed procedures for the correction of erroneous data or elimination of obsolete data. Further, and most important, is action necessary to safeguard private rights by establishing procedures to guarantee confidentiality of data. It is emphasized that all data are included, not just computer-based data. The problems of integrity and confidentiality of data are as old as democracy. The advent of computerized files has dramatized the problems; the computer has brought opportunities both for better control and for abuse.

Accordingly, it is recommended that the Legislature enact legislation establishing State and local government policy on integrity and confidentiality of all data and directing (a) the Commissioner of Information Systems, in consultation with appropriate officials of the State government, to establish programs and procedures to implement such policies and to insure their enforcement at the State level and (b) the Intergovernmental Commission on Information Systems (see Part V of this report) to develop the programs and procedures to implement those policies in local government. The Commissioner of Information Systems and the Intergovernmental Commission on Information Systems should give priority to this responsibility.

(Substantial research is being conducted by a number of different groups on the development of legislation and operating guidelines on these topics. One of these efforts was in conjunction with Project SEARCH, a federal — six state (including Minnesota) joint effort in the criminal justice area. The results of the SEARCH research on these matters was published in August 1970, and covers the topic in depth.)

Intergovernmental Coordination and Cooperation

In the area of information systems, DIS stands in a key position with respect to the Federal government, higher education, local governments, and vendors of systems and computer equipment and services. In every way possible, DIS should encourage and participate in cooperative efforts among and between these groups. Actions of which the following are representative should be taken by DIS.

- Encourage Federal agencies to fund the development and implementation of major information systems for State and local governments as, for example, has been done by the U.S. Department of Labor, Bureau of Employment Security, for the state departments (Minnesota Department of Manpower Services).
- Corollary to the above, encourage direct Federal and state participation along with local government in the development and implementation of local government information systems. Only in this way is there assurance that the resultant systems will have general applicability to local government.
- To the extent feasible, promote Minnesota State or local government agencies' serving as prototypes in systems development as suggested above.
- Encourage joint local government development of information systems, assisting where possible with State personnel and funding.
- Promote the utilization of existing, successful applications including individual programs as well as broader groupings of applications such as those developed by TIES; in the resulting implementation effort, assist with State personnel and funding when possible.
- Support with personnel and funding any programs of NASIS (The National Association for State Information Systems) to promote common systems, intergovernmental data interchanges, data and operating standards, and any other NASIS efforts furthering State and local information systems.
- Coordinate and assist with the development of data bases of statewide or regional value, such as MAPS at the

University of Minnesota and RAFT developed by the Citizen's League and the Upper Midwest Research and Development Council.

It is noted that Part V of this report emphasizes state-local cooperative and coordinative efforts.

Part II of this report contains a summary of the recommendations in Parts III, IV, and V along with a discussion of the interrelationships among the three main parts.

REFERENCES

1. North Star Research and Development Institute, **A Plan for an Information System for Minnesota State Planning,** (A Report to the State Planning Agency, State of Minnesota) *January 1967.*

2. Department of Highways, State of Minnesota, **Meeting the Electronic Data Processing Needs of the Minnesota Highway Department,** *October 1966.*

3. Planning Research Corporation, **PIMISS: Pennsylvania Interagency Management Information Support System,** (Prepared for the Bureau of Management Information Systems, Commonwealth of Pennsylvania) *September 1968.*

PART IV
HIGHER EDUCATION

PREFACE

The length and somewhat tedious detail of this study of computers in Minnesota higher education is at least as apparent to its authors as it will be to its readers. Section 1 of the report argues the necessity of computers in higher education today, in terms of the objectives of the five systems of post-secondary education in Minnesota. The final section, Section 5, presents 30 specific recommendations for providing Minnesota higher education with the computing capacity it needs over the next five- and ten-year periods, complete with estimated budget schedules and commentary on the relationship of the projected costs to national standards and other costs of higher education. By reading these two sections, the reader who lacks time to digest the entire report will be exposed to most of the important points and recommendations contained in it. In between, Section 2 covers the present status of computer facilities and activities in Minnesota higher education; Section 3 contains a quantitative analysis of the needs for computing capacity over the next ten years; and Section 4 converts this needed capacity into general computer hardware configurations and geographical deployments, and estimates the total costs involved. Those readers who are unfamiliar with computer systems using remote terminals may find it especially helpful to read Section 4.3, and perhaps Sections 4.1 and 4.2, to learn just what is involved in them.

Frequent reference is made in this part of the report to ten Appendices, labeled H.1 through H.10. These appendices contain information on the conduct of the study, papers written on special topics of importance to computer applications in higher education but which could not be covered adequately during the study, and details and tables of results from the analyses in Sections 2, 3, and 4 of the main report. These appendices are not bound in copies of the general report which also addresses information systems in state and local government. The interested reader may obtain a copy of the higher education report bound together with its Appendices from the Higher Education Coordinating Commission.

Finally, we should like to emphasize that, although the recommendations and development schedules in Section 5 are in a sense a "Master Plan" for computing in higher education in Minnesota, they cannot and must not be interpreted as specific, rigid implementation plans or schedules, but rather as guidelines for the development of specific implementation plans and for the evaluation of those plans. It is properly the function of the various systems and institutions of higher education to develop and propose specific, detailed implementation plans, and the function of the coordinating organizations and the State Legislature to evaluate and fund the plans. If this report is acceptable, it may provide a useful basis for planning and evaluation, but the hard work of detailed planning and implementation must be left to higher education itself.

ACKNOWLEDGMENTS

Whatever acceptance this report receives will be a result in part of numerous consultations with faculty members and administrators in many institutions and all of the systems of post-secondary education in Minnesota, as well as with several representatives of the computer industry. Most of these individuals are listed in Appendix H.1. The authors are most grateful to them for their generosity and hospitality in meeting with us, and apologize for any names which have been omitted inadvertently, misspelled, or incorrectly identified. Professor Russell W. Burris and Dr. Frank Verbrugge of the University of Minnesota, Dr. John E. Haugo of the State College Board, Richard Peterson of the State Department of Education, Banning Hanscomb, Donald Wujcik and Dr. Howard Bergstrom of the State Junior College Board, and Richard Paulson of Macalester College were especially helpful to us. Periodic reviews and encouragement from the Computer Advisory Committee of the Higher Education Coordinating Commission were important in shaping the report, as were information, advice, and technical support received from the staff of the Coordinating Commission, and especially from its Executive Director, Richard C. Hawk.

Minneapolis, Minnesota
September 1970

Peter G. Roll
Peter C. Patton

PART IV

HIGHER EDUCATION

TABLE OF CONTENTS

Description **Page**

1. INTRODUCTION 4-1
   - THE OBJECTIVES OF POST-SECONDARY EDUCATION 4-1
     - Instruction 4-2
     - Research 4-3
     - Public Service 4-3
     - Institutional Support of the Objectives of Higher Education 4-3
   - THE ROLE OF THE COMPUTER IN MEETING THE OBJECTIVES OF HIGHER EDUCATION 4-4
     - Administrative Data Processing 4-5
     - Educational Computing 4-5
     - Research Computing 4-6
     - Public Service Computing 4-8
     - Special Applications of Computers in Higher Education 4-8
     - The Necessity for Computing Facilities and Services in Higher Education 4-9
   - OBJECTIVES OF THE STATEWIDE STUDY OF COMPUTING FACILITIES IN HIGHER EDUCATION 4-10

2. A SUMMARY OF PRESENT COMPUTING FACILITIES AND PROGRAMS IN MINNESOTA HIGHER EDUCATION 4-11
   - THE UNIVERSITY OF MINNESOTA 4-11
   - THE STATE COLLEGES 4-12
   - THE STATE JUNIOR COLLEGES 4-13
   - THE PRIVATE COLLEGES 4-13
   - THE AREA VOCATIONAL-TECHNICAL SCHOOLS 4-13
   - OVERALL SUMMARY OF COMPUTING CAPACITY 4-13

3. GOALS AND THE COMPUTER RESOURCES NEEDED TO MEET THEM 4-17
   - EDUCATIONAL COMPUTING 4-17
     - Instructional Computing 4-17
     - Instructional Computing for Graduate Students 4-19
     - Research Computing 4-20
     - Summary of Educational Computing Needs 4-20
   - ADMINISTRATIVE DATA PROCESSING 4-20

Description **Page**

SPECIAL APPLICATIONS 4-24
  A Statewide Automated Library System 4-24
  Computer-Assisted Instruction 4-27
  Information Services 4-28

4. FACILITIES AND COSTS TO MEET THE GOALS 4-29
COMPUTER SYSTEMS 4-29
MASS STORAGE 4-39
INPUT/OUTPUT FACILITIES: TERMINALS AND COMMUNICATIONS 4-40
  Configuration of Remote-Terminal Computer Systems 4-40
  Terminals 4-40
  Multiplexors or Concentrators 4-40
  Modems or Data Sets 4-42
  Communication Lines 4-42
  Communications Controllers or Concentrators 4-43
  Staffing of Teleprocessing Networks 4-43
STAFF AND OPERATING SUPPORT 4-44
DEPLOYMENT ALTERNATIVES 4-44
  Procedures and Assumptions 4-44
  Specification of the Alternative Deployment Configurations 4-45
    University of Minnesota 4-45
    State Colleges 4-46
    State Junior Colleges 4-47
    Private Colleges 4-47
    Area Vocational-Technical Schools 4-47
      A Fully Regionalized Deployment for Higher Education 4-48
  Summary of Results for the Deployment Alternatives 4-48

5. RECOMMENDATIONS AND DEVELOPMENT SCHEDULES 4-51
RECOMMENDATIONS FOR MINNESOTA HIGHER EDUCATION 4-51
  Recommendations for Each of the Five Systems of Higher Education 4-53
    The University of Minnesota 4-53
    The State College System 4-55
    The State Junior College System 4-55
    Area Vocational-Technical Schools 4-57
    Private Colleges 4-57
  Recommendations Addressed to the Higher Education Coordinating Commission 4-58
A TIME-PHASED FIVE-YEAR PLAN 4-62
A SECOND FIVE-YEAR PLAN 4-65
THE PLANS IN PERSPECTIVE 4-72
PRIORITIES 4-74
REFERENCES 4-76
APPENDICES 4-77

LIST OF FIGURES

Figure		Page
1.1	An Organizational Structure Supporting the Objectives of an Institution of Higher Education (Suggested by Dr. R. W. Brady, Ohio State University)	4-4
2.1	Relative Spending for Computer Facilities, 1964-1969 Publicly Supported Colleges and Universities	4-16
2.2	Relative Spending for Computer Facilities, 1964-1969 Privately Supported Colleges and Universities	4-16
4.1	Computer Capacity Versus Cost	4-37
4.2	Configuration of a Remote Terminal Computer System	4-41
5.1	Statewide Plan for Computers in Higher Education	4-63
5.2	Public Funding for Computers in Minnesota Higher Education	4-71

LIST OF TABLES

Table		Page
2.1	Existing Computing Facilities Used for Instruction and Administration in Minnesota Post-Secondary Education, 1970-71 (includes those approved for acquisition)	4-15
3.1	Summary of Terminal and Peak Load Computer Capacity Requirements for Instructional Computing in Minnesota Post-Secondary Institutions	4-21
3.2	Need Estimates for Administrative Data Processing Capacity in Minnesota Colleges	4-25
4.1	Estimated Computer Capacities Required to Serve Minnesota Higher Education with Batch-Processing and Remote-Job-Entry Facilities in 1975-76	4-31
4.2	Estimated Computer Capacities Required to Serve Minnesota Higher Education in 1975-76 with Time-Sharing and Remote-Job-Entry, Batch-Processing, Using the Same Computers for Both	4-33
4.3	Estimated Computer Capacities Required to Serve Minnesota Higher Education in 1975-76 with Time-Sharing and Remote-Job-Entry Batch Processing, Using Separate Computers for the Two Modes	4-35
4.4	A Comparison of Three Ways of Supplying the Computer Capacity Required at the University of Minnesota and at the Minnesota State Colleges. Computer Cost Estimates are Monthly Lease Equivalents Extracted from Tables 4.1, 4.2, and 4.3	4-39
4.5	Summary of Monthly Equivalent Lease Costs Associated with Each of the Deployment Configurations Analyzed (1970 Dollars) .	4-49
5.1	Existing Computing Facilities in Public Higher Education by Function, 1970-71 (Including those Approved for Acquisition)	4-66
5.2	Proposed Funding Schedule for Computing Equipment 1971-75 (Purchase Basis, 1970 Dollars)	4-67
5.3	Proposed Funding Schedule for Computing Equipment to be Added During 1971-75 (Lease Basis; Annual Lease = 27% of Purchase Price, in 1970 Dollars)	4-68
5.4	Approximate Annual Incremental Operating Budget Needs (1970 Dollars)	4-69
5.5	Approximate Annual Total Operating Budget Neets (1970 Dollars)	4-70
5.6	Annual Cost Per Student of the Computing Capacity Proposed for Minnesota Higher Education in 1975, in 1970 Dollars (Derived from Table 4.5)	4-74

1. INTRODUCTION

During the past two decades, the development of electronic computing and data processing machines has had a profound impact on all aspects of American society — an impact unmatched by other technological developments in our history. Starting in the late 1940's as the esoteric research tool of a few scientists and mathematicians, computers have invaded almost every part of our economy and society. Science and engineering were the first areas; then came applications to fiscal operations of business and other large organizations, and to the operations of government. Computers have become the tools of the artist and musician, the literary scholar, the printer (automatic typesetting), the surveyor, the carpenter (job estimating), and even the taxpayer, who today can avail himself of several services which make use of remote, time-shared computer terminals to assist in filling out IRS Form 1040. Rather than merely automating traditional procedures formerly carried out by large numbers of clerks or engineers, electronic computing and data processing machinery has begun to change profoundly the systems and organizations which use them — business, industry, government, hospitals, education. To quote from a report of the President's Science Advisory Committee in 1967[1],

> After growing wildly for years, the field of computing now appears to be approaching its infancy.

A technology with this social impact must, and has, invaded higher education. The computer has evolved in higher education from an object and tool of research to both an object of instruction and a tool of instruction. This evolution has proceeded in a relatively uncoordinated way, in Minnesota as well as elsewhere in the nation. The evolution has by now progressed to the point at which the computer is beginning to have significant effects on the methods, content, and organization of higher education. It is the need for coordination of these efforts, and the costs of providing the computer and data processing facilities which they imply, which led to the present study.

This report will endeavor to provide answers to the following questions:

- Why are computers needed in higher education?
- How much computer capacity is needed to serve higher education in Minnesota?
- How much will this computer capacity cost?
- How can computer applications in Minnesota higher education be coordinated and organized effectively to provide the maximum benefits to students and society, at the least cost to the taxpayer?

As the location of a significant fraction of the American computer and computer-related electronics industry, the State of Minnesota has a special stake in the health of that industry, and in the vigor of programs in higher education which use or relate to the products of the computer industry. However, it will be the *objectives* of higher education in the various systems and institutions which form the basis for the analysis directed at the above questions, and for the recommendations at the end of this report.

THE OBJECTIVES OF POST-SECONDARY EDUCATION

Higher education in the United States traditionally has had three objectives:

- Instruction
- Research
- Public Service

Some kinds of institutions divide their efforts among all three missions, and others specialize in just one or two of them. To understand the place of computers in meeting these objectives today, it is important to have a clear understanding of what the objectives really mean, and which of the objectives apply to each of the five systems of higher education in Minnesota:

- The University of Minnesota
- The State Colleges
- The State Junior Colleges
- The Area Vocational-Technical Schools
- The Private Colleges

Although referred to in this report as "systems", the last two listed are not coherent systems in the same sense as the first three. The Area Vocational-Technical Schools are creatures of local government — Independent or Intermediate School Districts — coordinated by the State Board of Vocational Education and the State Department of Education. As such, they are represented indirectly in the other two major parts of this study, covering state agencies and local government. Sixteen of the private colleges are members of the Minnesota Private College Council, through which they are represented on the Higher Education Coordinating Commission. They do not form a "system" in any but the loosest sense of that word.

Each of the three objectives of higher education is now addressed in turn.

Instruction

Instruction of students is the primary reason for the existence of post-secondary institutions in this country, and for *some* of the institutions, it is their only objective. But there are three kinds of instruction which are distributed among the five systems —

- **General education of students to understand and appreciate themselves, other people, and the physical, social, and intellectual world in which they live.** This kind of instruction is an important function of the university, the state colleges, the private colleges, and transfer and some non-transfer programs in the junior colleges. In the classical sense, this objective is the heart of a liberal arts education. However, it does not play a major role in the Area Vocational-Technical Schools.

- **Vocational training.** This kind of instruction is the exclusive objective of the Vocational Schools, the vocational programs in the junior colleges, and certain vocational programs in the colleges and university. It is aimed at preparing students to enter a job and begin earning their pay within a few days after they start, on the basis of the specific training they have received. The jobs for which vocational training is provided are well defined, and it is relatively easy to establish a successful training program and determine whether or not a student has completed it satisfactorily.

- **Professional education.** The objective of professional training is not to produce graduates who can step into a job and begin producing immediately (although this may happen), but to prepare a person with a basic understanding of his field, the methods, techniques and tools used in it, and the discipline necessary to learn what is needed to do a job and to direct and manage others in getting it done. A person with professional training at the undergraduate or graduate level may be unable to perform many tasks as well as the graduate of a non-degree vocational program. But it is from this group that most of the managers and executives come, and the people whose work leads to new kinds of jobs for others, and new ways of doing old jobs. Most students in a liberal arts curriculum today acquire in addition a considerable amount of training relevant to some vocation or profession. Professional and pre-professional training is the responsibility of the state and private colleges and the university. Most of the advanced graduate education, and professional training in areas such as law, engineering, medicine, and other health sciences, is concentrated on the University of Minnesota's Twin Cities campus.

To maintain a viable system of post-secondary education meeting the needs of the state for trained manpower, an informed and articulate citizenry, and a satisfying life, Minnesota must support all three kinds of instruction. The results and payoffs of vocational and professional education are easiest to recognize, but the general level of understanding and sensitivity of the people, enhanced more by general education, may be as important to the welfare of our society in the long run.

Research

Research may be defined as the expansion of knowledge and the development of techniques, methods and devices for solving problems related to the natural world and to man and his institutions. It is on research that the progress of society depends. The principal resource of the State of Minnesota for research is the University of Minnesota. Within higher education, the state colleges and some of the stronger private colleges also have a mission which includes research, though to a lesser extent than the university. The junior colleges and area vocational-technical schools do not serve as research institutions, except in the broad sense applicable to all institutions, whether they are in education or outside, public or private: all institutions must carry out research on their own operations, to determine whether they are meeting their goals and how to increase their effectiveness and efficiency.

Much research is of value to the state and the nation in terms of its results and applications; this is a public service of higher education. But research is a *necessity* for institutions whose mission includes graduate and post-graduate professional education. The basic understanding, the ability to use the tools and methods, and most especially the self-discipline required to learn and to generate new knowledge when it is needed — these attributes are imparted to graduate and post-graduate professional students through their participation in research. Whether these students remain in research when they leave the university or pursue their field as practitioners in some other way, it is the research-generated self-discipline and self-motivation for continual learning which characterizes them as professionals, and in which the value of their education resides.

Public Service

In a broad sense, education and research are a service to society. In addition, however, institutions of higher education in the United States have traditionally provided more direct services to the public as part of their mission. This began with accurate time-keeping service to the local community by the college astronomer (before the days of widespread telegraphic communications and railroad time zones), and agricultural extension services through the land-grant colleges. Today public services are provided by colleges and universities not only to agriculture, but to businesses, schools and school districts, the health care industry, governmental agencies, the housewife, urban renewal projects — almost all segments of society. These services most often grow out of the other two functions of higher education. Instruction has led to evening and adult education classes, and large Extension and Continuing Education Divisions within various institutions. And many of the results and methods of research, particularly at the University of Minnesota, have been developed by faculty members, working in cooperation with outside groups, for application to some of the problems of a segment of society or of the state as a whole. If higher education were not performing these services, other institutions would have to be created to provide them.

Institutional Support of the Objectives of Higher Education

Just as have most other institutions of our society, higher education has grown large, complicated, and expensive. The organizational structures required to support college and university faculty in carrying out their three missions have become more conspicuous, more important, and also more costly. Two support services which directly affect and are necessary for the primary instructional function of higher education are:

- Student services — financial aid, assistance in obtaining living accommodations and meals, extra-curricular activities, etc.
- Learning resources — libraries, audio-visual media, television, laboratory equipment, and even the computer itself. All of educational technology and applied learning psychology would fall in this category.

These two activities draw upon the results of relevant research, and may carry out research and development work where it is needed to improve their support services. The results of this kind of development effort, as well as many of the resources used in higher education, are also available as a service to the public. The University of Minnesota Libraries, for instance, are a resource available to the people of the State.

Supporting and managing the operations of each institution and system of higher education is an administration which, through its respective governing board, is legally responsible to the public for the operation of the institution or system, and for the successful accomplishment of its missions. Administration must carry out the research and develop the information and fiscal systems necessary to effective and efficient management of the educational enterprise.

Figure 1.1 may be useful in illustrating the relationships between the three objectives of higher education, which are always uppermost, and the supporting activities required to achieve them effectively and efficiently.

THE ROLE OF THE COMPUTER IN MEETING THE OBJECTIVES OF HIGHER EDUCATION

Having defined the goals of higher education, it is necessary now to define the functional areas which need computing services or facilities, and then to justify the needs in terms of the goals of higher education. For ease of discussion, several different functional areas have been defined and will be discussed in turn.

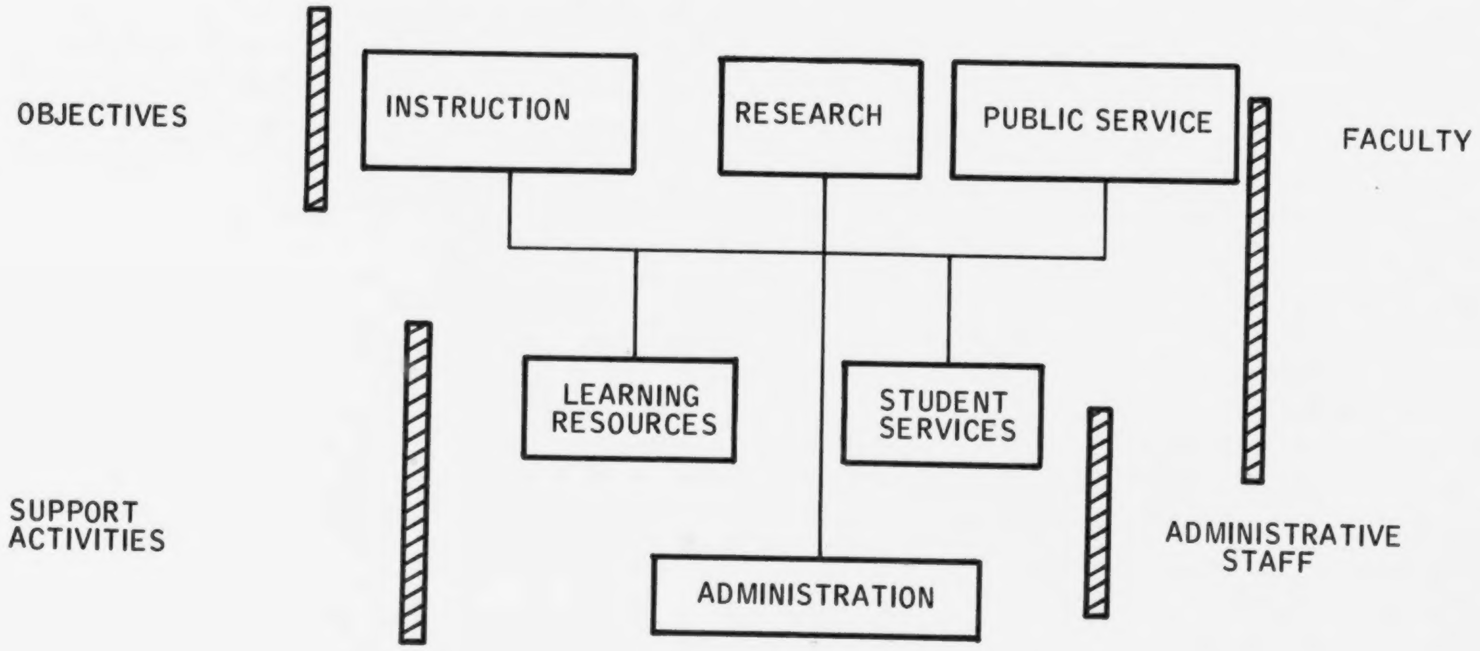


Figure 1.1. An Organizational Structure Supporting the Objectives of an Institution of Higher Education (Suggested by Dr. R. W. Brady, Ohio State University)

Administrative Data Processing

Student records, personnel files and accounts, financial records and transactions, property and space inventories, and curriculum and scheduling represent most of the administrative and student service activities in a college or university. These are tasks which lend themselves to electronic data processing, just as have the administrative data processing requirements of business, government agencies, and other large organizations. There is no essential difference between administrative data processing in institutions of higher education and in businesses or other organizations of comparable size and complexity. For this reason, the benefits of electronic data processing in higher education are similar to those which have induced many large businesses and industries to automate their administrative activities; namely, increased effectiveness in the form of better and quicker service, and increased efficiency in terms of decreased costs or costs which do not rise as fast as they would otherwise. The real benefits to be gained from administrative applications of computers are the development of effective college management information systems to improve the quality of the administrative support to students and faculty; and program planning and budgeting systems, so that it will be possible to determine true costs of programs, and to assign institutional priorities on a more rational basis using this information. Just as has been the experience in business, applications of computers will force a complete review and revision of administrative objectives, organizations and procedures, providing the institutions themselves, their governing boards, the Legislature, and the people of the State with much more adequate information on which to base decisions concerning the wise allocation of the state's resources.

Educational Computing

This is the computer application most closely related to the primary mission of higher education — instruction. But within this category, there are several kinds of computer applications which are quite different, and require some elaboration.

- **Instructional Computing** will be defined as the use of generally-accessible computers by students in all courses requiring computing, and by graduate students for their thesis work; that is, computing which is directly related to the student's learning activities and which is normally carried out on large or small general-purpose computing facilities. Except for courses in programming, the computer is used as a tool for learning (or a "learning resource"), rather than an object of instruction.

  The value of the computer as a problem-solving tool is readily apparent for students in such quantitative areas as engineering, science, accounting, and statistical analysis in the social and biological sciences. It may be less obvious, however, that computers have many instructional uses other than problem solving in academic areas ranging from engineering to the fine arts. Programs are in use which permit students to interact with a computer simulation of a bridge or building structure, an atom, a business operation, the political system of a city during an election, or a hospital patient. Using such simulation programs, students can acquire experience in making decisions and investigating the consequences of those decisions. The computer is being used successfully to analyze the expository writing of students in journalism courses at the University of Michigan. It is making possible student experience with using and interpreting information from large social data bases, such as the census data. And it has become an important medium for students in art and music at several colleges. These and many other instructional applications are described in the Proceedings of a Conference on Computers in the Undergraduate Curricula, held in June 1970 at the University of Iowa[2].

- **Computer Training** includes courses and programs in which the computer is an *object* of instruction rather than a tool. For instance, students in data processing and programming courses at area vocational-technical schools need hands-on use of either a computer or a remote-job-entry terminal. This is the environment in which they will be required to function when they get a job. Many vocational school graduates, in fact, begin their careers as computer operators, for which training in operating a *specific* computer system is not so important, but general familiarity with and experience in handling some kind of computer or terminal equipment is most important. For those students who have regular access only to a terminal, it is important that, sometime during their training, they visit a computer site for a few days of observation and hands-on experience in how a computer system functions – preferably one that handles remote as well as local processing. (These same remarks apply to the one junior college data processing program, at Lakewood State Junior College.)

There are also programs for computer maintenance technicians in operation or beginning at two of the area schools – Mankato and St. Cloud. Such programs require substantial access to computer hardware which can be taken apart and reassembled. Therefore, it simply cannot be used to provide computer service. The two schools with these programs have two of the largest computers in the state – a UNIVAC Athena and an RCA 501, respectively. Fortunately, these have been obtained as surplus at virtually no cost to the Minnesota taxpayer, so that these programs can operate on a reasonable cost basis.

The programs of the Computer, Information, and Control Science Department at the University of Minnesota, although aimed at a much different kind and level of student, are in certain respects similar to those in the area vocational schools. The graduate and perhaps advanced undergraduate training and research functions of this department, now in its second year of operation, require access to software and hardware systems with which the students can experiment. It is not feasible to carry out this kind of training on a computer system which must also provide service. Therefore, most major computer science departments throughout the nation have acquired special medium-sized or somewhat out-dated large computers for their own use (examples: Kansas University, Purdue, Case-Western Reserve). The University of Minnesota will need to do this in the near future.

- **Special-Purpose Laboratory Computing** is a form of educational computing which is becoming important – and even necessary – in certain specialized professional programs, particularly in engineering. For instance, the use of process control computers has become widespread in the chemical industry. As a result, many chemical engineering departments are using small computers as a piece of instructional laboratory equipment, to control unit operations and provide real-time analyses of chemical engineering systems for students in their laboratory work. In order for engineering education to remain abreast of engineering practice, this kind of educational computing, in which the computer is again a tool rather than an object of instruction, will become more and more necessary. While this type of educational application is now most apparent in a few engineering fields, it is very likely to become a significant factor in other sciences, and especially in the health sciences, over the next decade.

Research Computing

Computers were originally developed as research tools, and over the past two decades they have become indispensible to research in many of the fields pursued in major universities. Research computers can be grouped in three classes.

- **General-Purpose Service Facilities** available to the entire academic community for research and instruction. The major share of the research computing at colleges and universities is usually handled by computing facilities of this kind.

- **Special-Purpose Computing Facilities** are configured for and dedicated to specific application areas. Although they may be used for both instruction and research, and generally by students and faculty in certain academic areas, they usually are not suited to or readily available for use outside of these areas. Two examples of facilities of this kind at the University of Minnesota are the CDC 3300 in the Division of Health Computer Sciences, dedicated to and funded largely by the Federal Government for applications in medical science; and the Hybrid and Digigraphics Computer Laboratory, specializing in hybrid analog-digital computation and high-speed interactive computer graphics. Both of these facilities are used and are available for instruction and public service, although the major fraction of their use is for sponsored research. Correspondingly, they are funded largely through federal grants and income from services rendered to sponsored research projects (also mostly federal grants) and outside agencies. (See Appendix H.4 for a breakdown of costs and funding sources. The Division of Health Computer Sciences facility, for instance, was acquired with only 28% university or state funds, while about one-third of its computing load is directly related to instruction of students in the health sciences.)
- **Special-Purpose Computing Devices** built into research apparatus as part of the apparatus. Such computers are performing functions which cannot be accomplished effectively or efficiently, if at all, by a general-purpose computer. Functionally, they are serving not as computers, but as an integral part of the apparatus in which they are used. A useful analog is a telephone exchange: a modern telephone exchange could be called a computer — the equipment can and does do most of the things a computer does. Functionally, however, it is not a computer, but rather a message-switching device. Because of this functional distinction, and because they are funded almost exclusively by research grants and contracts or service fees, these special-purpose devices will not be considered further as computers.

These are the three categories of research computing facilities. As pointed out earlier, the functions of research and instruction are closely linked for graduate and post-graduate professional education. In this sense, research grants and contracts have contributed an important and substantial subsidy to this kind of education. It is important, therefore, to distinguish as *instructional computing* the unsponsored computing by graduate and post-graduate professional students related to their course work and thesis projects. This is computing for which the State *must* pay if it wishes to provide such advanced training. Sponsored research and other projects directly under the control of faculty members and related to professional activities in their academic field will be defined as *research computing,* even if some graduate students may be involved. This is not the best way to make the distinction, but it is a practical way.

The computer demands of research are that the general-purpose facilities and services be available when they are needed, and at a level sufficient to meet the demands; and that the institutions be organized to allow and assist faculty members to obtain and use appropriate special-purpose computing devices and facilities when outside funds are available for this purpose. Such computer needs should not and have not made demands upon institutional or state funds in any way different from the many other kinds of research activity which are supported from within higher education. For these reasons, this report will not undertake a detailed analysis of research computing in higher education: the service capacity must be there as excess above instructional needs. A major investment of state funds is not required, because most of this computing is supported from outside grants and contracts.

Public Service Computing

Much of the activity normally labeled "research" in higher education actually is a public service, involving development and research activities for public agencies. There are, for instance, many governmental agencies using the various computing facilities of the University of Minnesota, both in the Twin Cities and Duluth. State college regional centers may be expected to undertake many similar activities. Two examples exist for which a facility is almost exclusively dedicated to a public service application.

The IBM 360/30 computer located at the Agricultural Experiment Station in St. Paul is devoted to and funded by services to the Dairy Herd Improvement Association, and for soil analyses, farm management, and other agriculture-related activities. These applications are self-supporting. At the University Hospitals, a Burroughs 2500 computer is dedicated to hospital administrative data processing, patient monitoring, and other internal hospital functions. Again this facility is self-supporting as part of the hospital operations.

Since public service computing within higher education is almost completely supported through the services provided and does not require a direct outlay of state funding through the institutions of higher education, its needs will not be analyzed in this report. The computer capacity and willingness to provide service of a developmental nature must be there, but the required funding will come from the agencies served.

During the course of this study, it became apparent that there were three identifiable areas in which significant planning and development was underway for special applications of computers to the goals of higher education. Development effort devoted to each of the three areas has the potential of leading to more effective service for instruction, research, and public service, and for making the operations of higher education more efficient in providing these services — that is, reducing costs or preventing costs from increasing as rapidly as otherwise. The three special areas are discussed in more detail in Section 3, and two of them are dealt with in special reports appearing as Appendices H.2 and H.3. They are:

- **A Statewide Automated Library System.**

  The library is a major and expensive learning resource at every college and university, directly serving the needs of instruction, research, and public service. With the recent explosion in volume of printed information, libraries (and especially academic libraries) are being sorely taxed just to keep up with the volume of ordering, processing, cataloging, and shelving, to say nothing of providing adequate reference and retrieval services. To be optimally efficient, however, an automated library must serve the needs of all libraries in the state, not just the libraries in higher education.

- **Computer-Assisted Instruction and Computer-Managed Instruction.**

  These are direct applications of the computer to the instructional process — using the computer as an integral part of the process to administer and manage instruction. To do this successfully will require a careful assessment of the specific goals, methods, and content of instruction in each course and academic field, followed by an equally careful instructional design to utilize computers and other media in an optimum way. This will require the greatest development effort and will encounter the greatest resistance from those conditioned to traditional methods of instruction. But if successful, these applications also will bring the greatest payoff in terms of effectiveness and efficiency.

- **Information Services.**

  Information on population characteristics, natural resources, and similar distributed properties of the natural and social worlds is becoming increasingly important for purposes of public and governmental planning at all levels. Likewise, information of this kind, and the ability to process it, is an important learning resource for research and instruction, especially in the social sciences. These latter needs have led to an increasing involvement of faculty members with the development of large data bases of information which can be read and processed by computers. The potential value of information services of this kind, both to higher education and directly to the public, cannot be ignored by a Statewide Study of Computing Facilities in Higher Education, and is, in fact, linked closely to the other two parts of this overall report, covering State Government Agencies and Local Government.

Each of these three special application areas will be discussed in more detail in Section 3 of this report. Recommendations concerning them appear in Section 5.

The Necessity for Computing Facilities and Services in Higher Education

Having discussed the objectives of higher education and the functions that computers can serve in meeting these objectives, it is time to summarize three of the important reasons why computers are a *necessity* in higher education today.

First of all, there is a need for people trained and educated in computer programming and the various other aspects of computer science and data processing. With the size of the computer industry today, this need is obvious, but the size of the need is not. To quote from the 1967 report of the President's Science Advisary Committee, *Computers in Higher Education.*[1]

> There is inadequate information about the number and level of skills of personnel now employed in the field of computers, and there are no meaningful forecasts.
>
> We recommend that the Federal Government collect meaningful data concerning computers and the jobs, personnel, and educational facilities associated with them, and endeavor to make useful annual forecasts.

This recommendation has not been followed. Two articles in a recent issue of the trade magazine *Datamation* quoted rather disparate estimates of the national need for computer personnel:

50,000 per year[3], and 125,000 per year[4].

Even considering the present recession in the computer industry, 2% of the lower estimate, or 1,000 per year at all levels, is a reasonable conservative estimate of Minnesota's needs. Existing and planned programs will not saturate this need for some time to come.

Secondly, we need people educated to understand computers, what they can do and how to use them, and how to manage and direct their use in particular areas of application. More specifically, it is doubtful whether society can effectively use, or even tolerate, more social scientists, educational and business administrators, and workers in any number of other fields who are not trained in quantitative methods. Computers in higher education make it possible to train students in all fields in the use of quantitative methods to attack and solve problems.

And finally, there is a need for a general understanding of what computers can and cannot do, and how they affect the society in which we live. It must be understood that an incorrect billing, a lost order, or an inaccurate income tax refund cannot be blamed on computers, but usually are the results of human error. Only when a broad level of public understanding is achieved can the computer begin to reach its full potential. Higher education can help achieve this level of understanding directly by including some exposure to computing in the general education of most students, and indirectly by adequately educating those who will become school teachers and parents and affect the minds of future generations.

OBJECTIVES OF THE STATEWIDE STUDY OF COMPUTING FACILITIES IN HIGHER EDUCATION

Having argued the objectives of and needs for computing in higher education, it is the intent of the remainder of this report to:

- Summarize the existing (1970-71) computing facilities and applications in Minnesota higher education and their costs (Section 2);
- Analyze the needs of Minnesota higher education for computing facilities and services over the next five and ten years (Section 3);
- Determine the costs of various ways of meeting these needs, identifying the least expensive ways (Section 4);
- Recommend specific actions by the institutions and systems of higher education and the legislature to meet the identified needs and lay a sound basis for future development (Section 5).

The entire thrust of this study has been to determine the computing facility and service needs of the post-secondary students of Minnesota, in terms of the *objectives* of higher education, and to find and suggest ways of satisfying these needs which have the greatest likelihood of being implemented. To this end, educators and administrators from numerous institutions in all five systems of higher education and throughout the state were consulted extensively before the recommendations were formulated. The extent of these consultations can be judged from Appendix H.1. There is much evidence, in the form of similar studies in other states, to suggest that plans and recommendations developed without consulting extensively those people and institutions which must eventually implement them are unlikely to be accepted and implemented, regardless of their technical merits. In addition to this consultation within the state, the study benefited from the broader perspective of two consultants from other parts of the country. Dr. Ronald W. Brady, the Executive Assistant to the President of the Ohio State University (and now Administrative Vice-Chancellor of Syracuse University) offered advice on most of the matters related to the study. Dr. Robert M. Hayes, Director of the Institute for Library Research at the University of California and Vice-President of Becker and Hayes, Inc., was consulted on technical and organizational facets of plans for a statewide library automation system.

This study presents some estimates for needed computing facilities and services in isolation from the other important requirements of higher education. The final determination of the weight of the arguments and recommendations here, and the priority of computing among all of the needs of higher education, resides properly with the faculties, institutions, and systems of higher education, the Minnesota Higher Education Coordinating Commission, and ultimately the people of Minnesota through their elected representatives in the State Legislature. If it is generally acceptable, this report can provide guidelines for planning and evaluation by these groups, but it cannot be used *as a plan.* Specific, detailed planning and implementation is the responsibility of higher education, and this report represents only the beginning of that job.

2. A SUMMARY OF PRESENT COMPUTING FACILITIES AND PROGRAMS IN MINNESOTA HIGHER EDUCATION

The 1967 report of the President's Science Advisory Committee – the *Pierce Report*[1] – indicated the need for improvement in computing facilities and programs in higher education, and framed ten recommendations designed to bring the facilities of all higher educational institutions in the United States up to the standards of those schools which were best equipped at that time. These recommendations largely went unheeded, since the recommended federal funds of up to $400 million per year were not forthcoming. In several states *Pierce Report* goals were met to a greater degree than has been the case nationwide. In such cases, however, funds have been supplied by the respective legislatures of those states and have not come mainly from federal agencies. Computing in higher education is currently in a transition phase in this and many other ways: from federal funding toward state funding, from primarily research use toward instruction, and from use by the few toward use by the many.

The situation in Minnesota is not atypical. Most of the institutions of higher education in the state are not nearly so well equipped as the University or Carleton College. Yet even the University falls far short of the *Pierce Report* objectives and lags behind similar institutions in, say, Ohio or Wisconsin. On the other hand, the need for computer education and training may be greater in Minnesota than many other states, since it is a center for the design and manufacture of computers, and has a larger number of technology-based industries than many states.

As pointed out in Section 1, the requirements for computer education and training, and the corresponding programs and facilities at the post-secondary level, vary widely depending on the institution, its goals, and the career intentions of its students. The ensuing discussion will address the five areas or systems of higher education in Minnesota and will attempt to summarize their facilities and programs and to evaluate them with respect to their mission in computer education or training. Computers for administrative data processing will also be summarized.

THE UNIVERSITY OF MINNESOTA

The University is the largest institution of higher education in the state and is the best equipped with computer facilities. These computer facilities are summarized in Table H.5.1 of Appendix H.5, and their uses are summarized in greater detail in Appendix H.4. Three major general-purpose facilities serve the entire university for both instructional and research purposes. These are the CDC 6600 at the University Computer Center and the CDC 3200's at the West Bank Computer Center and the Duluth Campus. The overall instructional use of these facilities amounts to about 45% of their capability. However, their instructional use is growing much more rapidly than their research use (See Appendix H.4). To meet their needs for limited amounts of time-shared computing, which the University has no facilities to provide, several departments and research groups are spending their own supply funds to purchase service from commercial vendors.

Special-purpose computing facilities serve instructional, research, and public service needs but are more specialized in function or service area than the general-purpose facilities. The University's special-purpose facilities include the CDC 3300 of the Division of Health Computer Sciences, the IBM 360/30 on the St. Paul campus, used primarily for agriculture-related public service activities, and the Hybrid Computer Laboratory, with a CDC 1700 serving both a dual analog-digital hybrid computer system and an interactive graphic display system. Administrative Data Processing at the University is served by an IBM 360/50 configuration which, if augmented with additional disc storage, would have sufficient capacity to handle the batch and on-line processing requirements for an institution of this size.

In general, the computer facilities of the University are adequate for the programs underway or planned in the near future, with a few exceptions. The University has one of two undergraduate computer science degree programs in the state and the only graduate program. Especially for the graduate program, a computer is essential for student laboratory work and experimentation. The Center for Research in Human Learning has done considerable research and development in computer-assisted instruction but needs a computer system able to support the continued development and early production phases of this work. The IBM1500 instructional computer system, used for the early phases of their work and funded largely by the National Science Foundation, was discontinued by IBM and the NSF in early June 1970. Finally, the CDC 6600 has considerable unrealized potential for wider service which could be realized by providing central-site hardware and software to support remote terminals, both within the University and at other institutions. Also, it could be further enhanced as a job-shop computer by improving printer facilities. Most large-scale research computers used in an instructional environment are badly printer-bound, and the 6600 is no exception.

THE STATE COLLEGES

The computing capability in the State Colleges has evolved over the past ten years from several electronic accounting machine installations. Current facilities include IBM 1401 installations for administrative data processing, IBM 1620 centers for instruction, and some IBM 1130 computers for both, as shown in Table H.5.2 (Appendix H.5). Most of the existing applications are administrative in nature, leaning heavily toward student record-keeping, with some business or fiscal applications and a few institutional research programs. Approximately 1500 students within the state college system, or slightly less than 5% of total enrollment, are registered each quarter in classes which involve some sort of computer use. Only one of the colleges offers a major in Computer Science; but the others offer mathematics, physics, business, economics, or statistics courses which involve computer solution of problems.

As will be apparent from the analysis in Sections 3 and 4 of this report, the existing (September 1970) computing facilities within the state college system are inadequate by the norms of the *Pierce Report*[1]. However, this situation will be corrected by the major facility to be installed at Mankato late in 1970. If a similar machine is installed in St. Cloud in two or three years, and if the other state colleges have terminals to one of these machines in addition to their current capability, then facilities will be adequate for well over five years[5]. Demand for computer services at the state colleges has not been severe primarily because the available computer resources were so meager as to discourage serious use. The "double-hub" network planned for 1975 or sooner will be a major step toward correcting this situation and will encourage the development of computer and computer-related courses, as well as support the application of information systems technology to the management of the State Colleges.

It may be difficult to justify more than one additional Computer Science degree program in the state college system, and logically that would be located at the college with the second hub. It would be feasible, however, for the other colleges to develop major or minor degree programs in information sciences, management information technology, or elsewhere in the interdisciplinary areas between computer science, the administrative disciplines, and the basic sciences and mathematics. (Moorhead State College, for instance, has a Computer Science option associated with its Mathematics program.)

THE STATE JUNIOR COLLEGES

The State Junior Colleges have a centralized administrative data processing system based on a large IBM 1401 computer. Although this system gives good service, it does have limitations for planned increased enrollment and service levels. Until recently, the junior colleges had no computer service for instruction. Starting in the Spring of 1970, there have been teletype terminals at each college connected to the Honeywell EDINET time-sharing system, as shown in Table H.5.3. The 18 junior colleges share three computer ports. These terminals will support instructional programs and courses for which the computer is used as a tool. The only data processing curriculum in the system is at Lakewood Junior College, the site of the administrative data processing center.

THE PRIVATE COLLEGES

The range of computing facilities and instructional programs in the private colleges runs from more than adequate to non-existent. A few schools are able to expose a hundred to three hundred students to the computer in seven to ten or more courses in Computer Science or computer-related disciplines, as indicated in Table H.5.4.

Although fewer than half of the private colleges and junior colleges employ computers for instruction, most of them use computers, service bureaus, or electronic accounting machines for administrative data processing. Development costs appear high for a college to put administrative applications on a small computer. A group of seven Twin Cities colleges has organized a common program development and coordination effort to reduce these costs[6].

Most of the gaps in computing for private colleges in Minnesota could be closed by coordination of efforts to purchase or develop programs for college administration and by support for terminal facilities at each college and for central or regional computers to service the terminals. Some of the colleges are doing an adequate job with a small IBM 1130 computer and do not really need such terminal support. The University 6600 is available to private college faculty for their research needs on the same basis as it is to the University faculty and is now in the process of being made available via remote terminals at colleges. The Mankato Regional Computer Center will provide similar service.

THE AREA VOCATIONAL-TECHNICAL SCHOOLS

Several of the Area Vocational-Technical Schools have training programs for computer programmers (see Table H.5.5). However, some degree of computer service is also needed at those schools which have one or two-year accounting programs but do not offer programs in data processing. As pointed out in Section 1, data processing curricula in the AVTS have a somewhat different mission than do similar programs in colleges and the University.

There are no obvious gaps in the facilities or programs at the schools with curricula in data processing and with computers (Hibbing, Alexandria, and Mankato). They have excellent facilities and are graduating students well equipped to enter the business world as junior programmers. Those schools with data processing programs using IBM 1401 computers owned by their school district, or computer time donated or otherwise made available by local businesses, as well as schools with one and two-year accounting programs but without computer services adequate for at least COBOL instruction, would be well served with terminals connected to regional computers, service bureaus, or those AVTS with data processing curricula and computers.

OVERALL SUMMARY OF COMPUTING CAPACITY

There are two institutions offering degrees in Computer Science in Minnesota: Mankato State

College offers a B.S. degree, and the University offers B.S., M.S., and Ph.D. degrees in Computer, Information, and Control Sciences. An additional B.S. degree program at St. Cloud State College within the next five years would be tenable in terms of supporting facilities if the second regional center were to be located there. The data processing programs in the Area Vocational-Technical Schools provide instruction in computer technology as it is applied to data processing for business and industry. These programs conceivably might be augmented by one or two more such programs in the new vocational schools soon to open in the Twin Cities area.

On the administrative data processing side of higher education, there are many facilities and much activity but also much redundancy. National efforts are underway to allow comparability of data and use of common program packages. Information systems technology is just now finding its way into college and university management and holds promise for rationalizing the current undisciplined growth of applications, files, and programs into a more consistent approach. The introduction of Program Planning and Budgeting in universities and colleges is also encouraging the information systems approach.

Table 2.1 gives a summary of the major computer facilities currently existing in Minnesota higher education and their costs. A somewhat qualitative approach to placing the present computing capability of Minnesota higher education in perspective is to compare spending with other similar states or states with similar educational expenditures. Over the past five years, from 1964 through 1969, yearly expenditures for computer facilities in Minnesota higher education grew by a factor of four, with the greatest increase coming in 1967. A marked leveling off occurred in 1968 and 1969. Figure 2.1 shows the relative spending levels for computer facilities in the public sector of higher education in selected states during the past five years. Neighboring states were chosen for their similarity to Minnesota in economy, population, and certain higher educational factors. Except for Indiana, the comparisons are not surprising. In recent years public institutions in Illinois, Ohio, and Wisconsin have been somewhat better funded for computer facilities than have their counterparts in Minnesota. However, the differences are not large. In the private sector, Minnesota colleges are relatively worse off, not only as compared to private colleges in other states, as shown in Figure 2.2, but also as compared to publically-supported schools in Minnesota.

The computer industry marketing data from which Figures 2.1 and 2.2 were drawn include federally-funded computer facilities as well as state-funded facilities. It was impossible to separate these factors in the data for all the states shown, but those which were checked indicated that the total value of computers amounted to almost twice the cost of state-supported instructional facilities alone. Since the data were essentially comparable for all the states, it is their relative ranking which is significant.

Table 2.1. Existing Computing Facilities Used for Instruction and Administration in Minnesota Post-Secondary Education, 1970-71 (Includes those approved for acquisition)

Facility	Equivalent Net Purchase Price
UNIVERSITY OF MINNESOTA	
Instruction and Research Systems	
6600(a)(d)	$2,560,000
West Bank 3200(a)(d)	450,000
Duluth 3200(b)	440,000
Health Sciences 3300(a)(d)	825,000
Hybrid Computer(a)(d)	580,000
Time-Shared Computing from Commercial Services	60,000
Administrative System	1,500,000
STATE COLLEGES	
Small Computers (at all colleges)	967,000
Mankato Regional Computer	1,200,000
STATE JUNIOR COLLEGES	
Administrative Computer	163,000
HECC FUNDED PROJECTS(c)	253,700
Junior College Time-Sharing System	
State College Projects:	
Bemidji PDP-8 Mankato Computer Science Curriculum Development Southwest Academic Computing Moorhead IBM 1130 Support St. Cloud Instructional Time-Sharing Test Implementation of CAMPUS Management System	
AREA VOCATIONAL-TECHNICAL SCHOOLS	
Alexandria HW200	221,000
Mankato 360/25	233,000
Hibbing HW200	232,000
Moorhead	40,000
Willmar	40,000
PRIVATE COLLEGES (ESTIMATED)	850,000
TOTAL	$10,614,700

(a)These systems are used both for instruction and research. In Table 5.4, the operating budgets are for instructional usage only. For 1969-70, the instruction versus research usage was as follows: (a) 6600, 31% and 69%; (b) 3300, 33% and 67%; (c) Hybrid 20% and 80%

(b)For planning purposes, these systems are assumed to be 100% instructional.

(c)For both facilities and support.

(d)Significant fractions of the costs of these facilities came from federal or private sources (see Appendix H.4).

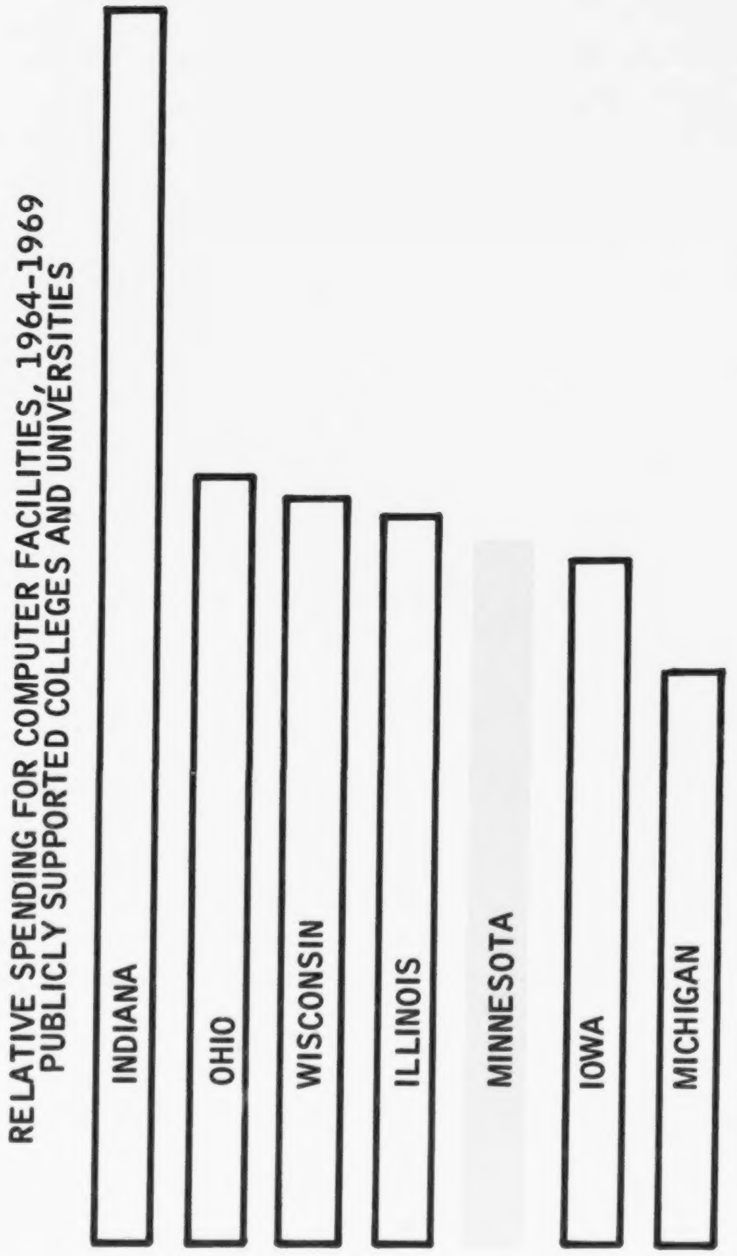


Figure 2.1. *Relative Spending for Computer Facilities, 1964-1969 Publicly Supported Colleges and Universities*

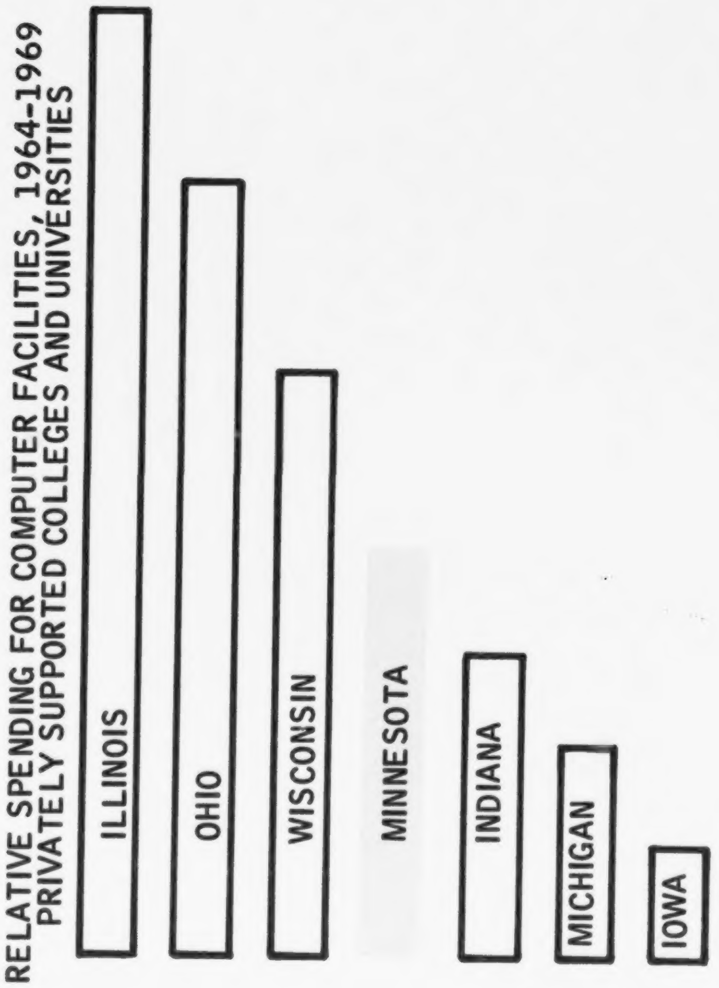


Figure 2.2. *Relative Spending for Computer Facilities, 1964-1969 Privately Supported Colleges and Universities*

3. GOALS AND THE COMPUTER RESOURCES NEEDED TO MEET THEM

How much computing capacity does the State of Minnesota need to provide an adequate level of computing services in higher education? This section presents quantitative estimates of the raw capacity needed in the two major application areas: educational computing (instructional computing and computer training) and administrative data processing. The analysis on which these estimates are based is presented in Appendix H.6; the goals of the estimates are:

- Achievement of the *Pierce Report*[1] objectives for educational computing for the State of Minnesota, i.e., to provide educational computing services for all of higher education in Minnesota equivalent to that available at the leading universities of the nation in 1967-68.
- Establishment of machine-readable data bases and an administrative data processing capacity which is sufficient to support the management information needs of institutions and systems of higher education and lay the basis for program planning and budgeting.

These quantitative estimates of capacity will be presented for the three major hardware components of computer systems:

- Input/output or terminal capacity.
- Central processor capacity.
- Mass storage capacity.

Three special application areas are also discussed: a statewide library automation system; computer-assisted and computer-managed instruction; and general information services.

EDUCATIONAL COMPUTING

Instructional Computing

Instructional computing is the most important area of educational computing for students in post-secondary institutions. For undergraduates the analysis in Appendix H.6 follows the methods of References (1) and (7) based on Minnesota rather than national or hypothetical data. The computing needs of graduate students were also incorporated into the analysis given in Appendix H.6. This analysis first classifies the various academic areas of study as to whether they involve substantial, limited, or casual use of computers. These categories are defined in Table H.6.1, and the major areas of study are classified in Table H.6.2 in Appendix H.6. These degrees of computer utilization by academic area, based on Minnesota student populations, cannot be considered precise. However, there exists no more reasonable basis on which to estimate instructional computing needs at the present time.

Because of the differences in the kinds of programs offered at the area schools and junior colleges, their computing needs were analyzed separately from those of the degree-granting colleges. In applying the results from Tables H.6.2 or H.6.3b in the Appendix, it must be kept in mind that they represent *averages* over a class of students. Although a student enrolled in a course in descriptive biology may use a computer not at all, another student in a beginning genetics course may use it twice as much as the typical "substantial" user.

The analysis in Appendix H.6 averages the number of problems per academic year in Table H.6.1 over the three usage categories weighted by Table H.6.2, showing that 11.3 problems per student are assigned on the computer per academic year. Assuming a 14-hour school day, 200 school days per year and 80% available time on the computer yields 2,240 computing hours available per academic year[7]. This analysis allows one to estimate the computing load for both a time-shared computing system (TS) using inexpensive low-speed terminals and a remote-job-entry system (RJE) with a much smaller number of medium-speed terminals.

Among computer scientists, computer center managers, and computer users there are considerable differences of opinion concerning the relative merits and costs of time-shared and batch-processed computing. Batch processing tends toward optimization of machine and operating system efficiency, while time-shared computing emphasizes the efficiency of the user at some apparent expense in hardware and software. It is apparent to us that most instructional applications of computers can be carried out on a batch processing system, either through remote-job-entry terminals or at the computer site. It is equally apparent that *some* of these applications could be carried out more effectively (in terms of student learning) on an interactive time-shared computer system, and that the educational value of other applications is severely damaged if time-shared computing is not available. Programs in which students interact directly with simulations of engineering, social, business, political, medical, and other systems are prime examples of this latter kind of application: the student decision-making process needs to be on-line with the computer program. It is shown in Appendix H.8 that, if time-shared computing capacity is used with a certain amount of discretion, it is not necessarily much more expensive than batch processing. Without dwelling further on these arguments, this report will proceed on the basis that *both* kinds of computing are necessary to meet the goals of higher education, and in about a 3:1 ratio of batch:time-shared computing.

A time-shared computer system will be defined here in terms of the user; it must include the following characteristics:

- Keyboard input/output, 10-30 characters/second.
- User may interact with his program during its execution.
- Response time of five seconds to a request not requiring significant computation.

The capacity of a time-shared computer system is measured in terms of the number of active terminals.

Table H.6.4 gives estimates of terminal hours per problem[7]. Averaging the loads estimated in Tables H.6.1, 2, and 4 over the three categories and dividing by the total available time yields 150 students per time-shared terminal in a college or university. The same analysis applied to junior colleges (Table H.6.3b) yields 333 students per terminal. Time-shared terminals are not suitable for vocational training in data processing, so their use has not been projected for area vocational-technical schools.

The dedicated computer capacity necessary to serve a given number of low-speed time-shared terminals can best be estimated as the number of active terminals serviced. Over the past several years, experience with several time-sharing systems of various sizes and costs has shown how many active terminals they can service adequately. Experience also suggests an average of one request per active terminal every thirty seconds[7]. Assuming the equivalent of fifteen FORTRAN statements compiled per request and a factor of two to accommodate peak loads leads to a compiling rate of 6.67 statements per second per 1000 four-year college students, and three statements per second for 1000 two-year college students.

The mass storage capacity of a time-sharing system may be estimated by relying on experience at the University of Minnesota and Reference (7), assuming that each active user needs an average of 3,000 characters of storage for his own programs and data. An average of the number of courses using the computer leads to a figure of about 40 percent of the total students in a college using the computer at any one time (Appendix H.6). The analysis indicates a need for 1.2 million characters per 1000 students at 4-year colleges and 600 thousand characters per 1000 students at 2-year colleges.

A remote job entry system employing remote batch access to a regional computer facility can also satisfy the needs established above. An analysis of the required capacity for this mode of operation is given in Appendix H.6 based on Tables H.6.5 and 6 and Reference (7). Assuming medium-speed RJE terminals which read cards and print at about 300 cards and 300 lines per minute, the total number of terminals required to serve 1000 students was estimated as approximately one-half RJE terminal per 1000 students at 4-year colleges.

Carrying out a similar analysis for the more limited needs of students at junior colleges yields about one-sixth RJE terminal per 1000 students. The obvious implication of this figure is that even a single RJE terminal has substantially more capacity than the largest Minnesota junior college needs for instructional computing.

The computer capacity needed to service these terminals is estimated on a peak load basis as 1.2 compiled FORTRAN statements per 1000 four-year college students per second, with 0.4 the corresponding figure for two-year college students.

Another way to furnish remote-job-entry computing is via low-speed terminals rather than medium-speed terminals. Although it is rather inconvenient for students to work with punched paper tape as an input medium from a simple teletype terminal, it can be done. Mark-sense card readers may also be attached to such terminals, increasing both their convenience to students and cost. About 20 low-speed terminals would be equivalent to one medium-speed terminal. The same amount of computing capacity will be needed for remote-job-entry regardless of the speed of the terminals used. The economic and pedagogical tradeoffs between low and medium-speed remote-job-entry and time-sharing are discussed in Appendix H.8.

A mixed time-shared/remote-job-entry system may be a better model of the operation mode of a regional computer center than a system which is only one or the other. As a basis for balancing the two types of usage, the analysis of Section 1.1.3 in Appendix H.6 yields the result that 13.3 time-sharing terminals are equivalent to a remote batch terminal. Assuming an additional 30% overhead factor for the time-sharing mode of operation, the analysis also indicates a requirement for seven times the raw computer compiling power to serve 1000 students in a time-sharing as compared to a batch processing mode. This is currently the mode of operation of the computer at the University of Minnesota – Duluth.

Instructional Computing for Graduate Students

The analyses in References (1), (7), and Appendix H.6 are directed to the computing needs of institutions which offer primarily undergraduate programs. As such, they suffice for all of the institutions in Minnesota except the Twin Cities campus of the University of Minnesota. The state colleges and the Duluth campus of the University all have graduate programs comprising a few percent of total enrollment.

Much of the instructional computing associated with these graduate programs will be course-related rather than large thesis research calculations, and it may be lumped together with undergraduate instructional computing.

The information on computer utilization at the University in 1969-70 in Appendix H.4 shows that graduate students consume a substantial amount of computing capacity not specifically related to their course work.

Using the data from Appendix H.4 on university computer utilization for 1969-70, plus enrollment data summarized in Appendix H.10, it was possible to develop a ratio between graduate and undergraduate student computer needs. This ratio of 3.5 between per-student graduate and undergraduate computing needs will be used, together with the enrollment projections summarized in Appendix H.10, to estimate the total needs of the University of Minnesota for instruction-related computing.

The data processing, computer programming, and computer science programs and courses in all of the systems of higher education provide specific vocational training for their students. The general requirements of these courses and programs have been included in the analysis of Appendix H.6, along with the specific requirements of computer training in the vocational schools. This analysis is based on 1974-75 enrollment projections in accounting and data processing from the State Department of Education. These presume that the 11 existing data processing programs will be increased to 13 by 1974-75, with enrollments ranging from 25 to 150. However, there is some question as to whether this many programs are needed. This issue is addressed in the recommendations in Section 5; but for the analysis in Appendix H.8, the present projections of the State Department of Education have been assumed.

Research Computing

As discussed in Section 1, the two systems of higher education which have a defined mission in research and graduate training are the University of Minnesota, and to a lesser extent, the state colleges. The computer capacity required to provide research services at the University will be excess capacity over and above the instructional computing needs. If the state colleges possess enough computing power to accommodate their instructional needs, they should have little difficulty in providing enough excess time to take care of most of their research needs. Certain particularly large computing or data processing problems may be more economically processed at the University's computer center, or eventually at one of the regional computer centers.

Summary of Educational Computing Needs

Table 3.1 summarizes the number of terminals, the computer capacity, and the special mass storage capacity required to meet the estimated needs for instructional computing of the specific institutions and systems of higher education in Minnesota for the academic years 1969-70, 1975-76, and 1980-81. For 1975-76 and 1980-81, the needs have been scaled according to total enrollment projections from the Minnesota Higher Education Coordinating Commission and the various systems of higher education (see Appendix H.10). The data obtained from these different sources is not always consistent, but any discrepancies and errors are far smaller than other uncertainties in this analysis. If the enrollment projections change significantly for any of the institutions or systems, then the figures in Table 3.1 must be adjusted accordingly. It should be noted that the capacity estimates are properly per 1000 full-time-equivalent (FTE) students, rather than being proportional to total enrollment (headcount). The extrapolation scaling is based, therefore, on the reasonable assumption that the ratio of FTE to total enrollment is constant from 1969 to 1981.

ADMINISTRATIVE DATA PROCESSING

An administrative data processing system for an institution or system of higher education will consist of data bases containing information for the following areas:

- Student Records
- Staff and Payroll
- Financial
- Courses and Curricula
- Space
- Property Inventory

Table 3.1. *Summary of Terminal and Peak Load*
for Instructional Computing in Minnes

	1969-70					
		Time-Shared System		Remote Job-Entry System		
Institution or System	Enrollment (FTE)	No. of Terminals	Peak Computer Capacity (FORTRAN Statements Per Second)	No. of Terminals	Peak Computer Capacity (FORTRAN Statements Per Second)	Projected Enrollment (FTE)
UNIVERSITY OF MINNESOTA	44,610	460	460	34.6	83.0	56,364
Twin Cities						
Undergraduate and Professional	33,519	224	224	16.8	40.3	38,000
Graduate	8,160(a)	190	190	14.3	34.3	11,520(a)
Duluth	5,279	35	35	2.6	6.3	8,050
Morris	1,565	10	10	0.8	1.9	2,900
Crookston	459	1	3	0.1	0.2	1,014
Waseca	–	–	–	–	–	600
STATE COLLEGES	35,528	237	237	17.7	42.7	46,090
Bemidji	4,652	31	31	2.3	5.6	5,790
Mankato	10,960	73	73	5.5	13.2	13,640
Moorhead	5,249	35	35	2.6	6.3	7,000
St. Cloud	8,863	59	59	4.4	10.6	11,160
Southwest	2,153	14	14	1.1	2.6	4,100
Winona	3,651	24	24	1.8	4.4	4,400
PRIVATE COLLEGES (4-YEAR)	27,627	184	184	13.8	33.2	33,800
Typical	1,000	6.7	7	0.5	1.2	
STATE JUNIOR COLLEGES	15,914	48	48	2.6	6.4	26,173
Typical	1,000	3	3	0.2	0.4	
TOTALS	123,679	929	929	68.7	165.3	161,227
AREA VOCATIONAL-TECHNICAL SCHOOLS (HEADCOUNT)	13,435(b)	–	–	23	84 Terminal Hours/Day	20,449

(a)Total enrollment figures have been used for graduate students, rather than full-time equivalents, for reasons explained in the text.
(b)See Appendix H.6 for an explanation of the Area Vocational-Technical School requirements. Terminals may be business minicomputer or regular terminals, or small stand-alone computers. AVTS headcount projections are for 1974-75 and 1979-80.

mputer Capacity Requirements
Post-Secondary Institutions

1975-76			[illegible]				
Shared System	Remote Job-Entry System			Time-Shared System		Remote Job-Entry System	
Peak Computer Capacity (FORTRAN Statements Per Second)	No. of Terminals	Peak Computer Capacity (FORTRAN Statements Per Second)	Projected Enrollment (FTE)	No. of Terminals	Peak Computer Capacity (FORTRAN Statements Per Second)	No. of Terminals	Peak Computer Capacity (FORTRAN Statements Per Second)
602	44.8	107.8	66,610	734	734	54.9	131.6
254	19	45.6	42,400	283	283	21.2	50.8
270	20	48.4	14,865(a)	347	347	26.0	62.4
26.8	4.0	9.7	10,400	69	69	5.2	12.5
97	1.5	3.5	4,150	28	28	2.1	5.0
1.5	0.2	0.4	1,560	5	5	0.25	0.6
0.9	0.1	0.2	800	2	2	0.12	0.3
308	23.0	55.4	58,040	387	387	29.6	69.6
39	2.9	6.9	7,180	48	48	3.6	8.6
91	6.8	16.4	17,000	113	113	8.5	20.4
47	3.5	8.4	8,710	58	58	4.9	10.4
74	5.6	13.4	13,870	93	93	6.9	16.6
27	2.0	4.9	5,750	38	38	2.9	6.9
30	2.2	5.3	5,530	37	37	2.8	6.6
225	16.9	40.5	37,200	248	248	18.6	44.6
79	4.2	10.5	32,200	97	97	5.2	12.9
1,214	88.9	214.2	194,050	1,466	1,466	108.3	258.7
	24	146 Terminal Hours/Day	39,850(b)	–	–	24	164 Terminal Hours/Day

2

Various applications programs access one or more of these files to produce automatically the reports, forms, records, checks, and other documents and data required for the administrative operations of the institution or system. Within higher education in Minnesota, the University of Minnesota has what is perhaps the most complete data processing system in operation and in the process of implementation. For this reason, and because adequate information was not as readily available from other sources, the University's system was taken as the basis for an estimate of the computer system capacity required to provide complete data processing services to all institutions in the state.

The units in which this capacity has been estimated are:

- Mass storage, in characters or bytes
- Input, in cards or similar record entries per year
- Output, in lines per year
- Computer transactions per year
- Required output rate, in lines per minute
- Required computing capacity in computer transactions per minute

The last two items are the limiting factors on computer system performance and, following the practice of Reference (7), these factors were estimated including peak load demands. The definition of a "computer transaction" was taken from the Auerbach Reports[8]; it consists of retrieval of a file from a random-access mass storage device (disk), updating the file, and returning it to mass storage and to a report file.

Details of the administrative data processing capacity analysis, complete with annotations on the various assumptions made in scaling the results to the different institutions, may be found in Appendix H.6. Summaries of the total capacity estimates for 1969-70, 1975-76, and 1980-81 appear in Table 3.2. The overall capacity results are assumed to scale within a system of institutions and with time according to the total enrollment. From an examination of the details in Appendix H.6, it will be seen that several other more relevant factors are used to scale various data file sizes or applications capacities. However, all of these factors increase and decrease with head-count. To facilitate scaling of the individual private colleges and state colleges, the figures are given in the tables in terms of a private college with 1000 students and a state college with 10,000 students. Area vocational-technical schools have not been included in the estimates of administrative data processing needs because their needs are unlike those of the other institutions of higher education, and they are parts of local independent or intermediate school districts. (See Section 2 in the Local Government part of the overall study.)

All of the factors entering into Appendix H.6 and Table 3.2 were reviewed by data processing management staff at the University, the State College Board, one state college, and one private college. Despite numerous questions concerning specific details, the estimates were confirmed as reasonable by these reviewers.

SPECIAL APPLICATIONS

As mentioned previously, the three special applications areas related to higher education and treated in this study are automated library systems; computer-assisted and computer-managed instruction; and information services.

A Statewide Automated Library System

The goals of a comprehensive statewide library system are to furnish several kinds of services to all libraries in the state through a centralized processing facility. The major kinds of services to be provided can be classified as:

1. Catalog production – production of Union Catalogs of holdings and of serials (periodicals).
2. Technical processing – book ordering and preparation, cataloging, and card production.
3. Information services – retrieval of bibliographic and archival information from available machine-readable data bases, such as the Chemical Abstracts, Library of Congress tapes, and archival census bureau tapes.
4. On-line bibliographic services for libraries throughout the state, providing rapid access and updating of holdings and other bibliographic information to all participating libraries.

All of these services are to be based eventually on a common bibliographic data base which will form the core of the system. Because of the magnitude of the job of assessing the technical soundness of the plans developed by the University Library Systems Staff, and identifying viable solutions to some of the serious interlibrary organizational problems that were apparent, an outside consultant who is a specialist in library systems was retained – Dr. Robert M. Hayes of Becker and Hayes, Inc., and Director of the U.C.L.A. Institute of Library Research. On the basis of an intensive three-day visit to the Twin Cities and the documentation produced by the University Library Systems Staff and various other librarians, libraries, and library agencies in the state, Dr. Hayes submitted a brief report and recommendations, which appear as Appendix H.2 of this study.

During and after his visit and subsequent to distribution of his report to a number of the library people involved, we have received numerous comments on Dr. Hayes' evaluation of Minnesota's statewide library automation plans. As far as the goals set forth in the Hayes Report are concerned they are agreed upon as good and necessary by the people concerned with libraries in the state. The overall development effort required to achieve the goals has been estimated by Hayes in Tables 5 through 9 of Appendix H.2, in terms of dollars per year. It ranges from $700,000 for the first year to $3.3 million in the fifth year; after this investment for development has been made, the operation would continue on a service-for-fee basis. The investment in a statewide library system probably will not reduce the costs of library operation overall, but it can greatly improve the services libraries can provide. And, if there is wholehearted participation and cooperation by all of the major public and academic libraries, then the costs of library operations can be prevented from escalating rapidly at the same time that service deteriorates. For example, if this central service were available it would not be necessary for each library in the state to acquire its own technical processing capability. On the basis of Dr. Hayes' report (Appendix H.2) and the reactions to it and to his visit, recommendations related to a statewide automated library system are made in Section 5 of this study. In addition, some comments appear there on the problems of organizational structures for operations across system boundaries, as they apply to library automation and as they are reflected in the Hayes Report.

Table 3.2.   Need Estimates for Administrative

	1969-70					
	Headcount	Mass Storage (Millions of Characters)	Required Output (Lines/ Minute)	Required Peak Computer Capacity (Transactions/ Minute)	Number of Query Terminals for Student Registration	Projected Headcount
UNIVERSITY OF MINNESOTA	50,415	660	986	2,200	101	63,050
Twin Cities	42,884				85	50,150
Duluth	5,580	36	54	123	11	8,500
Morris	1,510				3	2,800
Crookston, Waseca	441				2	1,600
STATE COLLEGES	37,681	328	496	1,067	76	48,844
Bemidji	4,716	41	62	133	10	5,857
Mankato	12,090	105	159	343	24	15,045
Moorhead	5,235	46	69	148	11	6,988
St. Cloud	9,557	83	126	270	19	12,028
Southwest	2,206	19	29	63	4	4,209
Winona	3,877	34	51	110	8	4,717
STATE JUNIOR COLLEGE SYSTEM	17,544	123	215	422	36	29,080
PRIVATE COLLEGES (4-Year)	27,137	400	325	1,055	–	33,189
Typical	1,000	11	12	39	2	1,000

ta Processing Capacity in Minnesota Colleges

1975-76				1980-81				
lass torage illions of racters)	Required Output (Lines/ Minute)	Required Peak Computer Capacity (Transactions/ Minute)	Number of Query Terminals for Student Registration	Projected Headcount	Mass Storage (Millions of Characters)	Required Output (Lines/ Minute)	Required Peak Computer Capacity (Transactions/ Minute)	Number of Query Terminals for Student Registration
327	1,240	2,790	126	74,350	885	1,460	3,280	149
				57,050				114
45	68	188	100	11,000	49	80	244	22
			17	4,000				8
			3	2,300				5
426	645	1,383	97	61,412	533	808	1,741	123
51	77	166	12	7,286	63	96	206	15
131	199	426	30	18,713	163	247	532	87
61	92	198	14	8,691	75	115	246	17
105	159	341	24	14,961	130	197	424	30
37	56	119	8	5,895	51	77	167	12
41	62	133	9	5,866	51	76	166	12
204	356	698	60	35,450	248	435	851	71
490	398	1,290	–	36,427	538	437	1,420	–
11	12	39	2	1,000	11	12	39	2

2

Computer-Assisted Instruction

As discussed in Section 1 of this report, the computer can be used not only as a tool by students (instructional computing), but also as an inherent part of the educational process – as a device to present material, problems, and decision situations and respond to a student's answers, solutions, and requests on the basis of his individual performance (computer-assisted instruction, or CAI) – and as a device to aid a teacher in managing the progress of a student through an instructional experience tailored to his individual needs (computer-managed instruction, or CMI). Whether the computer can be efficient and effective in these tasks is not yet known; there are optimists and skeptics both. It is imperative that higher education find out whether it is feasible to use computers in this way, for two reasons.

Firstly, the computer has the potential to enhance greatly the effectiveness of education in certain fields – to increase the effectiveness and efficiency with which students learn certain kinds of skills and concepts, as in foreign language and some areas of medical science; and to accommodate the presentation and pace to the different needs of individuals. Secondly, the computer may be an efficient, less expensive way to provide education in those areas where it is effective, as compared with traditional methods in higher education. A major cost in education is the cost of highly-trained manpower, which is largely determined by prevailing salaries and wages based on productivity of goods and services in other parts of the economy. In higher education there is no "product" with an easily-defined market value in the usual sense. And there has been, until recently, no way of increasing "productivity" in higher education to keep the total cost from soaring to levels that represent a significant burden to the taxpayer, the parent, and the student. Computer-assisted and computer-managed instruction offer the *potential* for significant economies to reduce the rate at which the costs of higher education increase. Although success cannot be guaranteed, the potential payoff is great enough to justify, or even demand, a modest investment for research and development.

On the basis of this kind of assessment of the economies and effectiveness of higher education, as well as some limited experience in the medical sciences, the Ohio State University has recently decided to make a substantial investment in CAI development and has acquired a computer system costing about $25,000/month (Class D in Table H.7.1) for this and other instructional resource applications. With a much smaller investment over the past two years, the Center for Research in Human Learning at the University of Minnesota has developed a staff with more experience and, in our opinion, a much sounder fundamental understanding of the basic and applied problems of instructional design and CAI than exists at Ohio State, or at any but a very few universities in the world.

The Executive Officer of the Minnesota Center for Research in Human Learning, Professor Russell W. Burris, has prepared for this report a paper which appears as Appendix H.3. His paper summarizes in greater detail the potentials of CAI for effectiveness and efficiency; some of the questions to be answered and development problems to be solved before it should be implemented on more than an experimental basis; the costs of this development; and some of the potential per-student costs if the development succeeds. The eventual costs which Professor Burris cites – $0.34 to $1.60 per student hour – are less than or comparable to the present costs of conventional instruction. However, they possess the notable advantage that costs of computer applications tend to decrease (or at least remain constant) as technology advances, while wage rates, upon which the costs of traditional instruction are based, change in the opposite direction.

In addition to this activity in CAI, two Minnesota institutions – Southwest Minnesota State College and Macalester College – are planning development efforts in the computer management of training for school teachers. This offers similar possibilities for increased effectiveness and attention to the needs of the individual student, as well as efficiency in terms of cost economies. It is expected that the development efforts at these two colleges would benefit substantially from contact with and support from the Center for Research in Human Learning.

The specific recommendations of this report on CAI and CMI development, based on these considerations and on Professor Burris' paper in Appendix H.3, may be found in Section 5. The goals toward which these recommendations are directed are four:

1. To find out whether CAI or CMI can significantly increase the effectiveness of higher education in specific fields and more nearly tailor the instructional materials and strategies to the diverse individual needs of students;
2. To establish the real costs of CAI and CMI and determine to what extent these represent savings which will slow the rise in total costs of higher education;
3. To involve faculty members from all systems and institutions of higher education in the state in the development effort, and to disseminate information on the work so that results may be adopted and adapted to as many institutions as possible and as quickly as they are proven to be efficient and effective;
4. To develop pilot programs in a number of disciplines, and to establish CAI learning centers from which formal instruction is available using CAI and CMI technologies.

Information Services

Several information retrieval projects have developed in various departments of the University of Minnesota as a part of their research programs. Some of these, such as the Diabetes Information Center in the School of Medicine, are very specialized. However others, such as RAFT (Rapid Analysis Fiscal Tool) and MAPS (Minnesota Area Planning Service), are much more general in nature and could serve statewide information needs which are much broader than the research programs of certain departments or schools. At the present time these information services are in a developmental rather than operational or "production" stage, and thus are in the proper research province of the University; however, as they near operational status and begin to attract a clientele from industrial firms and government agencies, they should be funded and managed like other statewide information services and resources.

Perhaps the best way to encourage the development of RAFT and MAPS and carry them into operational status would be to fund them through the Computer Services Division of the Department of Administration by means of contracts to the University departments involved in their development. As these systems become operational, then the State can take over their management as a statewide information resource.

4. FACILITIES AND COSTS TO MEET THE GOALS

This section will summarize the kinds of facilities available in mid-1970 to meet the goals estimated in Section 3 for the instructional computing needs of Minnesota higher education, and for providing the administrative data processing capacity needed for efficient and effective college management and program budgeting. The facilities and order-of-magnitude cost estimates for the computers themselves will be identified in terms of remote-job-entry (RJE), time-sharing (TSS), and mixed (RJE and TSS) systems. For administrative data processing and vocational school computing, both batch processing and the RJE mode of operation are considered. Much of the supporting detailed analysis for this section is contained in the tables in Appendix H.7.

It is not the intent of this report to configure computer systems in detail to meet the specific needs of institutions but rather to give general indications of the kinds of facilities needed for various applications and their costs. The mention of specific hardware does not mean that the hardware configuration will necessarily perform the task indicated at the cost given. This kind of information is included only to provide a general idea of the size of the system involved for those who are familiar with computer systems. The cost estimates could easily be low by a factor of two or high by 25%. In other words, this report can provide useful feasibility and background information of a general nature, but it should *not* be used as the basis of a system design.

COMPUTER SYSTEMS

Table H.7.1 in Appendix H.7 establishes a scale of computer systems according to their raw computing and data processing capacities and their cost ranges. This scale ranges from Class A – the most powerful and expensive computers available today – through Class I at the opposite extreme. Figure 4.1 displays the contents of Table H.7.1 in graphical form. The results summarized in Table 3.1 for instructional computing, and in Table 3.2 for administrative data processing, have been converted into the units used in Table H.7.1 and Figure 4.1. In Tables 4.1, 4.2, and 4.3 are displayed the estimated computer capacities required to achieve in 1975-76 the goals of Section 3 for Minnesota higher education. The approximate costs shown in these tables are for the computer only; they do not include terminals, operating support, or any of the other indispensible items discussed below. Furthermore, the computer costs are based on commercial rates and do not reflect the educational discounts and federal grants which often substantially reduce these costs to the state.

Each of the three tables shows a different way of achieving the goals:

Table 4.1: **Systems which support only batch processing via local and remote terminals.** However, it is not feasible to use medium-speed remote-job-entry terminals for junior colleges. The largest of them in 1975-76 (about 3000 FTE students) could use only half the capacity of a terminal, and two-thirds of them would use a terminal to less than 20% of capacity. Therefore, these colleges (and the Crookston and Waseca campuses of the University) will require service from a Class Z time-shared computer, as in Table 4.3, at a hardware cost of about $14,000/month.

Table 4.2: **Systems which support time-shared and batch computing on the same computer.** Reasonable assumptions are made concerning the fraction of instructional computing on each campus which would be in each of these modes.

Table 4.3: **Separate computer systems to support batch processing and time-shared computing.** This arrangement is based on the observation that most instructional uses of time-shared computing involve small programs or programs which require interactions with the user during execution rather than large amounts of computation. Programs requiring large amounts of scientific computing are run more effectively, more quickly, and at less cost in a batch processing mode. Hence, the power and variety of programming languages and systems available on a large computer are not needed for instructional time-sharing. The least-expensive Class Z time-shared system can be used to serve these needs.

Table H.7.1 and Tables 4.1 through 4.3 require a number of comments. First of all, the capacity and system cost figures in Table H.7.1 are all very approximate. They are based upon benchmark tests published in the Auerbach Reports[8], on other published information, and on the personal experience of the staff of Analysts International Corporation. Computer systems of specific manufacturers are mentioned only to provide some relation between the table and the real world. Depending on the application, a particular computer at a specific price may perform considerably better or worse than the table indicates, or than another computer with which it is classed.

Figure 4.1 shows that, with the exception of the largest computer systems (Class A and B), the rate of compiling FORTRAN statements increases in direct proportion to costs. In the middle of the range, the data processing capacity increases more rapidly than this, but that is not true for small or large computers. Neither the compiling nor the data processing rates rise as fast as predicted by Grosch's Law, for which a doubling of cost is accompanied by the quadrupling of the raw computing (arithmetic) capacity. This is because the computing associated with both administrative data processing and instruction is much more dependent on input/output and manipulation and interpretation of non-numerical information than is the straight scientific computing to which Grosch's Law applies.

The required computer capacities listed in Tables 4.1 to 4.3, in units of FORTRAN statements compiled per minute, represent the minimum compiling and computing speed for satisfactory instructional service during the busier times of the year. In Section 3, a peak load factor of two was included in these numbers, which means that if all instructional computing were distributed uniformly over a 14-hour day, 200-day academic year, then the computer capacity required would be about one-half that listed in Tables 4.1 to 4.3. Such a uniform distribution is clearly impossible in practice and, were it attempted, would destroy the educational effectiveness of the computer for all but a few students and faculty. As long as this kind of rigid, uniform scheduling is not applied to other educational resources, such as classroom, office, and laboratory space; expensive laboratory and audio-visual equipment; library facilities; and

Table 4.1. *Estimated Com*
with Batch-Pro

	Administrative Processing	
	(Lines/minute)	(Tra per
UNIVERSITY OF MINNESOTA	1,240	2
Twin Cities		
Duluth	68	
Morris		
Crookston, Waseca		
STATE COLLEGES	645	1
Bemidji	77	
Mankato	199	
Moorhead	92	
St. Cloud	159	
Southwest	56	
Winona	62	
STATE JUNIOR COLLEGE SYSTEM	356	
Typical Junior College (Enrollment ≃ 1,000)		
PRIVATE COLLEGES	398	1
Typical Private College (Enrollment ≃ 1,000)	12	

---

[a] For administrative processing only.

[b] For instructional computing only, including Twin Cities and Morris campuses.

[c] State college needs could also be handled by:
1) a Class D computer for instruction + Class E for administrative processing,
2) two Class D's at regional centers, providing about 70% of one as excess ca

[d] To provide the two-year campuses with instructional time-shared computing under hardware.

[e] Assumes 50% of total Duluth workload processed locally and the remainder in the

uter Capacities Required to Serve Minnesota Higher Education
essing and Remote-Job-Entry Facilities in 1975-76

equired	Instructional Capacity Required		Computer Class Required (Table H.6.1)	Approximate Monthly Lease Cost $
sactions inute)	Number of Terminals	(FORTRAN Statements/minute)		
790	–	–	E+[a]	30,000
	39	5,640	C or 47% of B[b]	65,000 (C) or 40,000 (47% of B)
188[e]	4.0	582	F	12,000
	1.5	210	–[b]	–
	0.3	36	–[d]	–
383	23.0	3,320	D+[c]	45,000
166	2.9	414	G	8,000
426	6.8	985	F+	15,000
198	3.5	504	G	8,000
341	5.6	805	F+	14,000
119	2.0	294	H+	6,000
133	2.2	318	H+	6,000
98	4.2[d]	–[d]	F-[a,d]	10,000[a,d]
	0.16		–	–
290	17	2,440	E+	30,000
39	0.5	72	I+	3,500

a total of $65,000/month, or
city, at $80,000/month.

is plan would add about $14,000 per month for

win Cities.

Table 4.2. *Estimated Computer Capacitie*
Time-Sharing and Remote-Job-

	Administrative Processing Required		I
	(Lines per minute)	(Transactions per minute)	% TS
UNIVERSITY OF MINNESOTA	1,240	2,790	–
Twin Cities			25
Duluth	68[d]	188[d]	25
Morris			50
Crookston, Waseca			100
STATE COLLEGES	645	1,383	25
Bemidji	77	166	25
Mankato	199	426	25
Moorhead	92	198	25
St. Cloud	159	341	25
Southwest	56	119	25
Winona	62	133	25
STATE JUNIOR COLLEGE SYSTEM	356	698	100
Typical Junior College (Enrollment ≃ 1,000)	–	–	
PRIVATE COLLEGES	398	1,290	25
Typical Private College (Enrollment ≃ 1,000)	12	39	25

[a] For administrative processing only.

[b] For instructional computing only, Twin Cities and Morris campuses.

[c] Morris, Crookston, and Waseca are accommodated on the Twin Cities campus computer.

[d] Assumes 50% of Duluth workload processed locally.

equired to Serve Minnesota Higher Education in 1975-76 with
try, Batch-Processing, Using the Same Computers for Both

ructional Capacity Required Time-Shared Computing		Instructional Capacity Required Batch Processing via Remote Job-Entry				
No. TS Terminals (Active)	(Statements per minute)	% Batch	No. RJE Terminals	(Statements/ minute)	Computer Class Required (Table 4.1)	Approx. Monthly Lease Cost $
–	–	–	–	–	E+[a]	30,000
131	10,380	75	30	4,230	B[b]	85,000
14	511	75	3	436	F	12,000
10	383	50	1	105	c	
5	426	0	0	0	c	
77	3,020	75	18	2,489	C	65,000
10	382	75	2	310	F	12,000
23	900	75	5	739	E	25,000
12	462	75	3	378	F	12,000
19	736	75	4	604	F+	16,000
7	270	75	1.5	220	G	8,000
8	290	75	2	238	G	8,000
79	2,350	–	–	–	E+	30,000
55	2,230	75	12	1,830	D+	52,000
2	66	75	1	54	H-	4,000

2

Table 4.3. *Estimated Computer Capacities Required to Serve*
Sharing and Remote-Job-Entry Batch-Processing,

	Administrative Processing Required		Instructional Capacity Required Time-Shared Computing		
	(Lines Per Minute)	(Transactions Per Minute)	% TS	No. TS Terminals (Active)	(Statements Per Minute)
UNIVERSITY OF MINNESOTA	1,240	2,790	–	–	–
Twin Cities			25	131	10,388
Duluth	68[d]	188[d]	25	14	511
Morris			50	10	383
Crookston, Waseca			100	5	426
STATE COLLEGES	645	1,383	25	77	3,020
Bemidji	77	166	25	10	382
Mankato	199	426	25	23	900
Moorhead	92	198	25	12	462
St. Cloud	159	341	25	19	736
Southwest	56	119	25	7	270
Winona	62	133	25	8	290
STATE JUNIOR COLLEGE SYSTEM	356	698	100	79	2,350
Typical Junior College (Enrollment ~ 1,000)	–	–			
PRIVATE COLLEGES	398	1,290	25	55	2,230
Typical Private College (Enrollment ≃ 1,000)	12	39	25	2	66

[a] For administrative processing only.

[b] For instructional computing only, Twin Cities and Morris campuses.

[c] Assume a Class Z time-shared computer, the hardware cost of which is $6,000/active terminal, or $150/month per active terminal. This does not include operating support.

[d] Assumes 50% of Duluth workload processed locally.

innesota Higher Education in 1975-76 with Time-
ng Separate Computers for the Two Modes

Instructional Capacity Required Batch Processing via Remote Job-Entry			Computer Class Required (Table 4.1)		Approximate Monthly Lease Cost for Computers		
Batch	No. RJE Terminals	(Statements/ Minute)	Time-Shared[c]	Batch	Time-Shared $	Batch $	Total $
–	–	–		E+[a]			30,000
75	30	4,230	Z	D-[b]	20,000	50,000	70,000
75	3	436	Z	F-	2,100	9,000	11,100
50	1	105	Z		2,250	–	2,250
100	0	0					
75	18	2,489	Z	D	11,550	35,000	46,550
75	2	310	Z	H+	1,500	5,000	6,500
75	5	739	Z	F-	3,450	10,000	13,450
75	3	378	Z	G	1,800	8,000	9,800
75	4	604	Z	F-	2,850	10,000	12,850
75	1.5	220	Z	H+	1,050	4,500	5,550
75	2	238	Z	H+	1,200	5,000	6,200
–	–		Z	F-[a]	11,850	10,000	21,850
75	12	1,830	Z	E	8,250	25,000	33,250
75	1	54	Z	I+	300	3,000	3,300

2

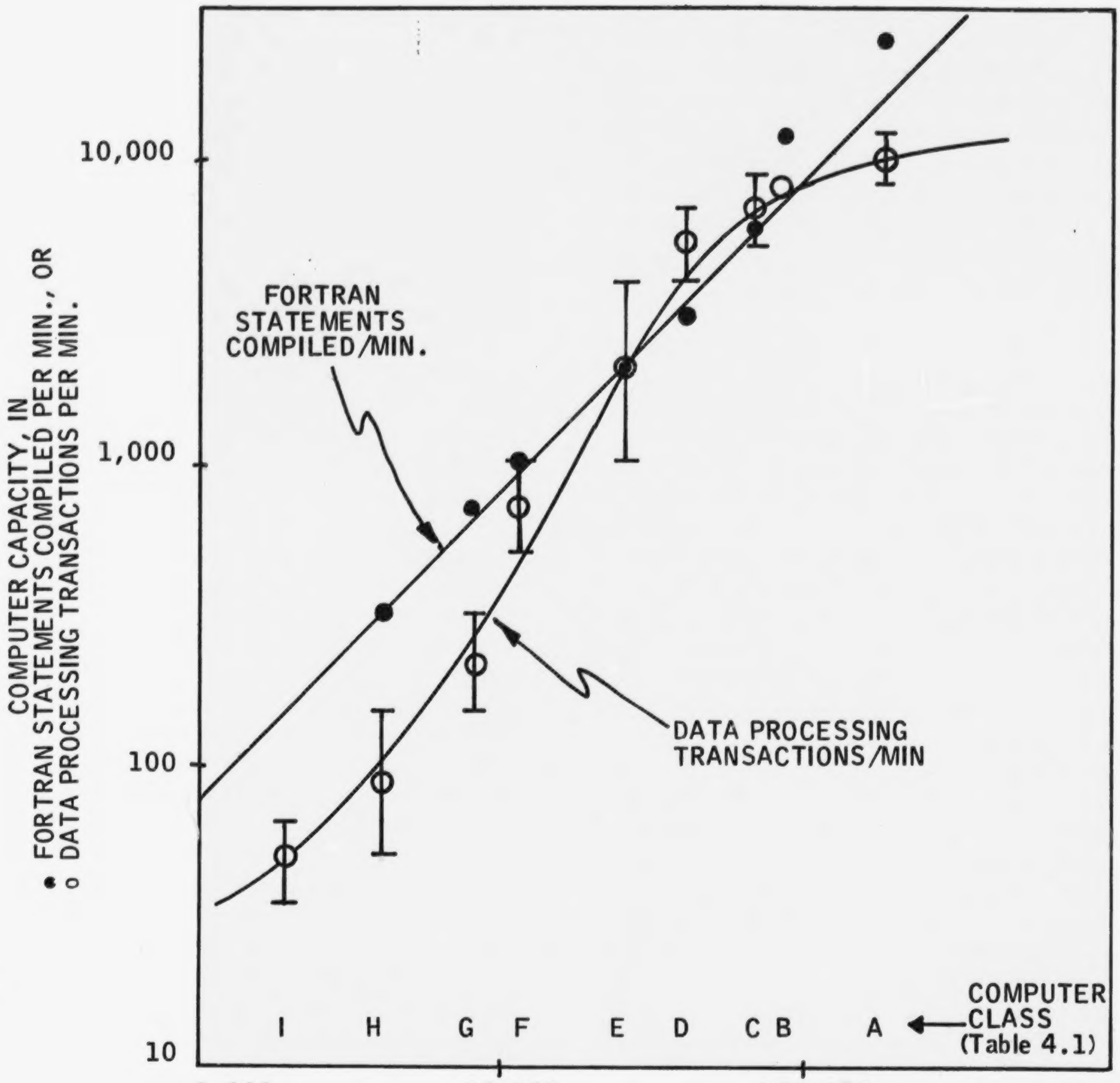


Figure 4.1. Computer Capacity Versus Cost

meal schedules and facilities, then it cannot be expected to work for computers. On the other hand, the peak load factor of two will not eliminate significant queuing and delays during busy periods, providing students with considerable incentive to work during non-rush hours. It is thought that the factor of two is a reasonable compromise between minimum cost service which is educationally inadequate, and maximum convenience service which is too expensive.

With this definition of computer capacity in mind, it will be noted in Table 4.1 that to adequately service their instructional needs in 1975, the Twin Cities campus of the University of Minnesota will require a computer with just under half of the compiling capacity of their existing Class B CDC 6600. About half of the computing at the University is for faculty research and public service applications (see Appendix H.4); it is expected that this will continue to be true over the next decade. It appears that this research and public service load can be accommodated in that half of the effective computer year outside of the 200 14-hour school days, plus in the background time available during school days. Users from other institutions of higher education can probably be serviced during this background time, too, at a higher priority level than lengthy research and public service jobs. But with all these demands on it, the capacity of the University's computer will be pressed in 1975. We expect that it will need to be expanded or replaced with a larger computer early in the second half of this decade. This analysis is consistent with that made by Dr. Frank Verbrugge, Director of University Computer Services, using an entirely different and independent method, and included as Appendix H.4 of this report.

Another interesting observation from Table 4.1 and Figure 4.1 is that the University's Class B computer is, in fact, more economical than a smaller system more nearly matched to the actual instructional needs of the University. The Class A and B computers, which were designed specifically for efficient FORTRAN compiling and large scientific and engineering calculations, lie in fact substantially above the capacity-versus-cost graph for smaller systems (Figure 4.1). By moving to a computer with 50% less capacity, which would handle the instructional load for the university in 1975 and very little else, it would be possible to save not 50%, but rather about 18% of the computer costs. In addition to the very substantial reduction in all research and public service applications, this move would sacrifice both the capacity to process efficiently certain kinds of large scientific and engineering design problems for which the Class B computer was designed, and the federal government's contribution of 31% of the computer's purchase price specifically to support this capacity at the University (see Appendix H.4).

It appears from Table 4.1 that there is a considerable cost saving associated with a centralized state college computer ($52,000/month) as opposed to computers at each state college (a total of $68,000/month). This cost saving, however, will be partly offset by the additional communications lines required to link four or five state colleges to centralized facilities. These tradeoffs will be dealt with in more detail later.

A comparison of Tables 4.2 and 4.3 indicates that it is considerably more economical to provide time-shared computing from a small Class Z system dedicated to that kind of service than it is to provide it from a large computer, whether that large computer is used also for batch processing (Table 4.2) or is dedicated to time-sharing (Table H.7.1b). This is one place where economies of scale do not appear, provided that the service needs of time-sharing users are limited to relatively small jobs in a limited variety of programming languages. As mentioned above, this does tend to be true of instructional time-shared computing. The results in Tables 4.1, 4.2, and 4.3 show that it is just slightly more expensive to furnish some of the instructional computing via a Class Z time-shared system than entirely by batch processing, while there is a considerable cost increase associated with providing the same amount of time-shared computing on the same computer which supplies the batch processing. These comparisons are shown more directly for the state colleges and the University in Table 4.4. In Appendix H.8, a more complete comparison of time-shared computing and various kinds of remote-job-entry computing is given.

Finally, a general observation may be extracted from the comments above. The greatest computer efficiency can be achieved by using a machine especially designed for a particular kind of job and avoiding a mix of different kinds of computing on the same machine. Hence, instructional time-shared computing is least expensive on a small, dedicated system; large scientific calculations are best carried out on the extremely fast Class A or B computers which were designed for such applications; and administrative data is most efficiently processed on computers in Class D or E, at the knee of the cost-capacity curve in Figure 4.1.

MASS STORAGE

Mass storage for data and programs is an indispensible and expensive feature of any general-purpose computer system. In the past, punched cards have been used as the mass storage medium for many computer systems, especially small ones. This medium is needlessly bulky and difficult to handle, store, and access. The two common mass data storage media at present are magnetic tape and magnetic discs or drums. The important difference between these two is that data must be accessed sequentially on magnetic tape but can be retrieved at random from any location on a disc or drum. Hence, tape is an effective and inexpensive medium for storing information which is usually referenced in serial or sequential order. High-speed disc and drum storage is far more effective when fast and frequent access to randomly distributed data is required.

The computer systems in the scales of Table H.7.1 include appropriate mass storage for the usual instructional computing applications. In particular, the time-shared computer systems are configured with enough disk capacity to provide about 3000 characters of program and data storage for each user.

The amount of data storage required for administrative applications is quite large and, therefore, is listed separately from the computer capacity. Approximate costs for mass storage units and the control units required to connect them to a computer are listed in Table H.7.2. Using the mass storage estimates from Table 3.2 and monthly costs for typical storage systems from Table H.7.2, the amount and cost of mass storage is shown in Table H.7.3 for each of the systems of higher education. Rather than using average or typical cost estimates, monthly costs of particular mass storage systems were employed, since in most cases the computer system with which the storage subsystem would work was

Table 4.4. A Comparison of Three Ways of Supplying the Computer Capacity Required at the University of Minnesota and at the Minnesota State Colleges. Computer Cost Estimates are Monthly Lease Equivalents Extracted from Tables 4.1, 4.2, and 4.3.

	Batch Processing Only	Batch plus 25% Instructional Time-Sharing on Same Computer	Batch plus 25% Instructional Time-Sharing on Class Z TSS Computer
University of Minnesota, Twin Cities (Instructional Computing Only)	$65,000/mo.	$85,000/mo.	$70,000/mo.
State Colleges-Centralized System for Instructional and Administrative Computing	$45,000/mo.	$65,000/mo.	$46,550/mo.

known. It was assumed that only 40% of the storage requirements given in Tables 3.2 or H.7.3 would have to be on-line at one time, and this is reflected in the monthly cost estimates given in Table H.7.3.

There is one major consideration which increases the cost and difficulty of storing and maintaining administrative data in a computer system — security. Special attention must be given to the use of hardware devices (memory protect), software and operating system design, and procedures for maintaining duplicate backup records to prevent unauthorized access to data and to minimize the possibility of accidental or intentional destruction of data. The costs of attention to this matter are intangible and are usually lumped into system operating support and maintenance. The costs of overlooking the security problem are intolerable.

INPUT/OUTPUT FACILITIES: TERMINALS AND COMMUNICATIONS

Configuration of Remote-Terminal Computer Systems

A remote-terminal computer system is rather more complicated than it may appear to the casual user or observer. Figure 4.2 illustrates the components in a typical system involving multiple terminals of both the low-speed time-shared and medium-speed remote-job-entry variety. A system dedicated to serving only one kind of terminal simply will not have any of the hardware attached to the other kind of terminal. The low-speed terminals are assumed to transmit at ten characters/second or about 110 bits per second (bps) — the standard teletype transmission rate. The medium-speed RJE terminals will be assumed to function at a rate of 2400 bits per second, corresponding to an input/output rate of about 300 cards/minute or 300 lines/minute, assuming fifty characters per card or line.

The components involved in a system of the kind illustrated will be described individually in terms of what they do and about how much they cost. It should be kept in mind that the prices quoted are typical prices, and that prices of components from various manufacturers, which can do more or fewer useful things than may be illustrated here, may vary from those quoted by factors of two or more.

Terminals

This is the basic input/output device. The simplest and least expensive terminal today is a teletype (TTY), which can be had with or without a paper tape punch and reader for off-line preparation and fast, automatic transmission of input data. Although a TTY can be used for remote-job-entry, it is rather slow and inefficient for this application; it is usually used for time-shared computing, providing the capability for preparation and debugging of programs and interaction with programs during their execution. Card and mark-sense document readers and graphic recorders are available which can be controlled by TTY terminals to increase their efficiency or effectiveness. Also becoming more available are terminals and accessories which operate at thirty characters per second. These are much more effective for large amounts of output and input via punched tape or mark-sense cards.

At the other end of the spectrum is a terminal consisting of a small computer with the ability to preprocess and format input data for more efficient transmission and utilization of the central computer facilities. Table H.7.4 displays the spectrum of terminal types, their approximate costs, and some examples of terminals currently in widespread use. The terminal classes have been identified with lower-case letters, ranging from Class h, including the most powerful and expensive small computers which are likely to be used as terminals, down to Class m, the slowest and least-expensive terminal (a teletypewriter).

Multiplexors or Concentrators

A single telephone line is able to handle data transmission at rates of 2000 to 2400 bits per second with no special equipment, and at rates of up to 9600 bps with special modems and line conditioning. A multiplexor is a device which

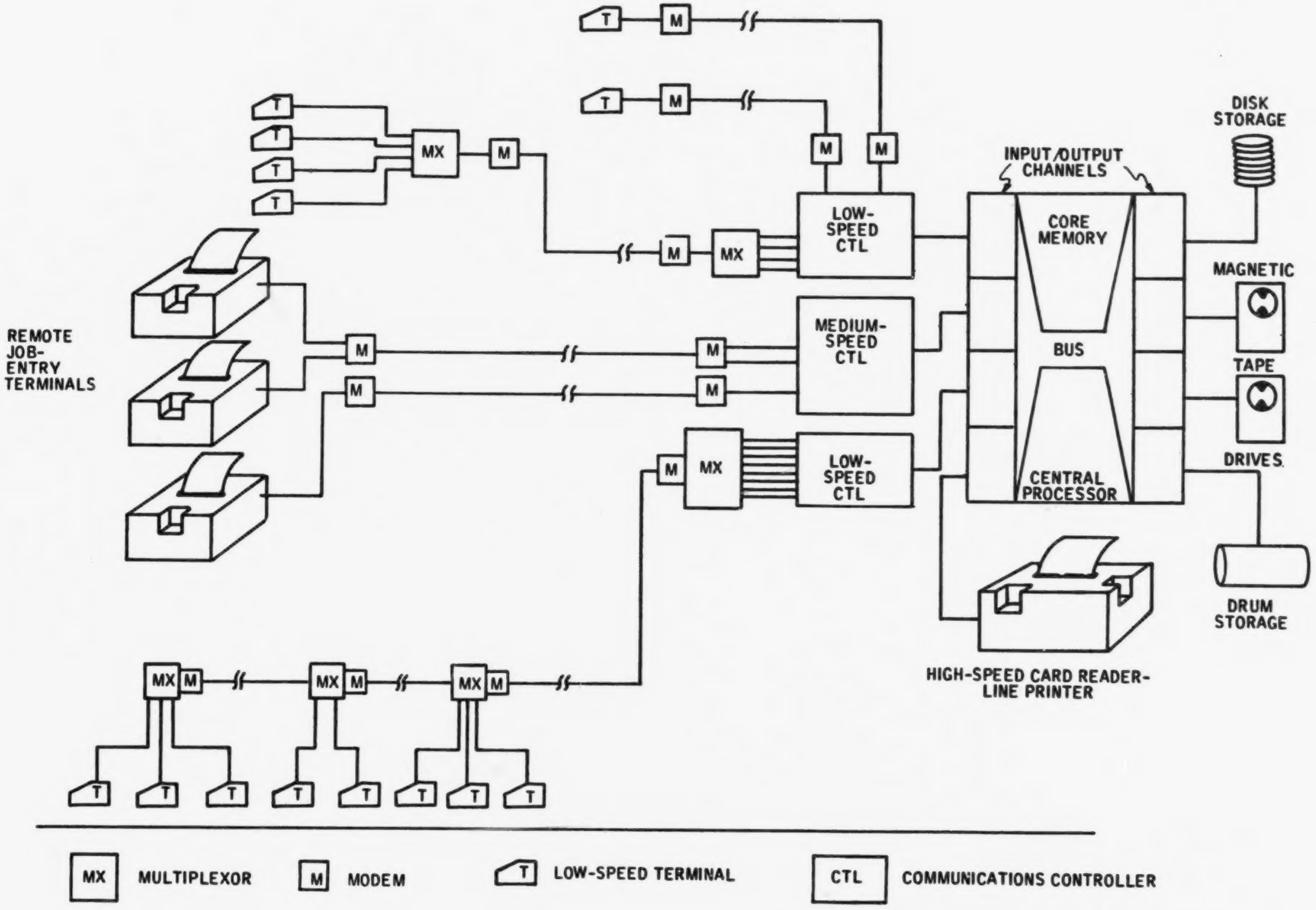

T
M
MX
LOW-SPEED CTL
MEDIUM-SPEED CTL
INPUT/OUTPUT CHANNELS
CORE MEMORY
BUS
CENTRAL PROCESSOR
DISK STORAGE
MAGNETIC
TAPE
DRIVES
DRUM STORAGE
HIGH-SPEED CARD READER-LINE PRINTER
REMOTE JOB-ENTRY TERMINALS
MX MULTIPLEXOR
M MODEM
T LOW-SPEED TERMINAL
CTL COMMUNICATIONS CONTROLLER

Figure 4.2. Configuration of a Remote Terminal Computer System

permits the output from two or more terminals to be combined for transmission over a single telephone line, often allowing substantial savings in communications costs. For instance, it is possible to concentrate as many as 16 to 24 low-speed teletype terminals (110 bps) into a single "voice grade" telephone line, and two medium-speed 2400 bps RJE terminals into a single telephone line. At the other end of the line (the computer site), a similar multiplexor will be required to separate the incoming signals into the original multiple-terminal channels. Table H.7.5 in Appendix H.7 describes a variety of types of multiplexors and their costs.

Modems or Data Sets

For transmission over telephone lines, the pulses from terminals must be converted into audio tone signals. At the other end they must be converted back into electrical pulses for transmission into the computer. The device which accomplishes this transformation in both directions is called a modem (modulator-demodulator), or data set, or Data-Phone (Bell System trade name). Modems are designed to operate at specific data transmission rates — the faster the rate, the more expensive the modem. Modems are also designated as synchronous or asynchronous, depending on whether or not the series of tone pulses representing a character are transmitted one at a time, or in blocks of characters with the pulse timing strictly controlled by a clock oscillator. Some multiplexors have modems built into them, so that they do not need to be supplied separately. The characteristics of several different kinds of modems are described in Table H.7.6 of Appendix H.7.

Communication Lines

The only sources of communication lines for data transmission within the state at present are the common carriers, Northwestern Bell Telephone Company, other private telephone companies, and Western Union. Within the next ten years it is possible that other communications carriers may offer data transmission service, and it is a recommendation of this report that a study be made of the feasibility of a statewide network for communications of all kinds between all units of government and education. For our purposes here, however, we have no choice but to describe the characteristics and costs of presently-available communication line services.

This information is listed in Table H.7.7 for the facilities appropriate to data communications in higher education. These are all voice-grade lines. It is unlikely that higher education itself would generate enough data traffic over any route to warrant the much more expensive wide-band transmission lines handling 40,000 bits/second and up. (However, the communications needs of all governmental agencies could cost-justify such lines over certain high-traffic routes. This possibility will be a major part of the feasibility study of a statewide communications network.) Certain data links will be used for rather limited amounts of time for which the regular long-distance dial-up network will be more economical than leased-line or WATS (Wide Area Telephone) service. An example is a state college with a computer tying into the University's 6600, particularly in the early stages of such an inter-institutional arrangement. The information in Table H.7.7 will enable institutions to determine when it becomes more economical to switch from dial-up to another form of service. The GSA lines in Table H.7.7 are lines leased at bulk rates by the federal government and made available at very low cost to agencies of state and local government when and where extra capacity exists. Information on the availability of these lines between the locations of most institutions of higher education is maintained by the Telecommunications Division of the State Department of Administration.

Finally, the state itself now leases a number of communications lines to serve the needs of its various agencies and offices throughout the state. These lines and facilities are tabulated in Table H.7.8, and it may be possible to arrange for limited use of a few of them for data communications. Since these lines are intended for voice communications between offices, they are not available during normal daytime hours;

and in some cases they must be kept open after hours as well. Unfortunately, the WATS lines from St. Paul are OUTWATS, while for communications between a terminal and a computer, INWATS lines are needed. Since the heavy need of large numbers of students for instructional computing must be accommodated during the day, the presently-existing leased lines will be of little use. They may be of major importance, however, for processing certain kinds of long research calculations from remote locations where both terminals and an available state tie-line or WATS line happen to be located.

Communications Controllers or Concentrators

When data arrives at the computer from remote locations, it must be collected and concentrated into bunches of complete data records (i.e., complete lines of input or messages) and fed into the computer in a high-speed stream or a fast burst; otherwise the processing speed of the computer would be slowed down by many orders of magnitude to match the data input rate from a single terminal. The device which accomplishes this task is a communications controller or concentrator. The characteristics and costs of some typical controllers are listed in Table H.7.9. A controller is, in effect, a message processing and switching computer. Some of the more effective teleprocessing computer systems, in fact, employ small "front-end" computers as concentrators. This is another example of a computer being dedicated, effectively and efficiently, to a task other than computing.

Staffing of Teleprocessing Networks

Any teleprocessing computer network involving more than a few remote terminals and communications lines must be designed and engineered with some care, installed, and maintained. This is especially true of networks using multiplexors and medium-speed and multi-channel modems. If all of the equipment is obtained from one of the common carriers, then their monthly rates will include the design, installation, and maintenance of the system. When equipment is leased from other vendors, they usually will provide routine maintenance as part of the lease cost; if purchased rather than leased, most vendors offer maintenance contracts on their equipment for a monthly fee. But if a network is as complicated as those to be described later for a junior college-private college-university time-shared computing service, or for a multi-user interconnected state college system, then the communications network must either be leased from the telephone company or Western Union, or the managers of the system must obtain staff to design and supervise the installation and maintenance of the communications. The minimum staff for this purpose would be one highly competent communications engineer. This staffing problem must not be forgotten when comparing costs of common carrier and independent vendor facilities.

A similar problem arises with the maintenance and servicing of terminals and other communications hardware. At some point, when there is enough equipment of this type, it may become more economical to hire a technician or two to maintain and service it rather than paying a monthly service charge to the vendor. Decisions on such matters should weigh not only costs, but also service and reliability. An instructional computing network *must* be reliable if it is to be educationally useful and effective. Recent reports from several NSF-funded regional computer networks in higher education have documented the importance of careful design and maintenance of the communications part of the network as well as the computer part[9].

At present, communications engineering support would have to be provided by whatever group is responsible for operating a communications network — a state college or the university, for instance. A capacity to provide this kind of service to higher education as well as other governmental agencies may develop in the State Telecommunications Division. This division may, in fact, develop the capacity to design, implement, and manage a complete communications system linking a terminal to the communications controller. These possibilities will be under study during the coming months.

STAFF AND OPERATING SUPPORT

One of the major components of cost in any computer installation is the operating support — staff salaries, maintenance, and general supplies and expenses which are too numerous to detail. Any estimate of the cost of computing which ignores these expenses will be highly misleading. In a business or industrial environment, medium and large-scale data processing installations seem to incur operating costs which are about twice the monthly rental cost of the hardware they use. Estimates made at the University of Minnesota's Computer Center show operating costs (salaries, maintenance, supplies and expenses) about equal to the equivalent monthly rental of the equipment. For small data processing installations in business and industry, operating costs may be considerably greater than two times the equivalent monthly rental[10].

Experience indicates that computer operations in higher education require somewhat less staff support than in business, because much programming is done by faculty and students as part of their job instead of by paid programmers and analysts. At the least, this is true for educational applications of computers. To estimate operating costs for educational computing, it has been assumed that operating costs equal equivalent monthly rental costs at prevailing commercial rates (not including educational discounts). The monthly rental includes the computer system, mass storage, terminals, and communications, while operating support covers keypunches (five or six for each remote-job-entry terminal, or per 2000 students) and other input peripherals, as well as staff salaries, maintenance, supplies, and expenses. Administrative data processing is assumed to require twice the equivalent monthly rental in operating expenses.

DEPLOYMENT ALTERNATIVES

Procedures and Assumptions

The number of ways in which the educational and administrative computer resources of higher education *could* be deployed is indefinitely large. The number of alternatives has been scaled down to manageable size by employing the criterion of educational effectiveness, by recognizing the existence of computing facilities at certain locations now, and by some gross cost considerations. The resentments and vested interests occasionally encountered between or within the systems or institutions were given no weight. As discussed more extensively in Section 5, these and other political considerations may make certain alternatives entirely unworkable, *unless* a user-directed policy board is established for facilities serving several institutions.

Some complex organizational factors must be addressed if inter-institutional and inter-system services such as the statewide library system and regional computer centers are to be workable. Such experiments have been shown to be workable in other states, e.g., libraries in Ohio and regional computer centers in Iowa. The key to success in such an endeavor is a user-oriented organization. If services are offered to a group of users on a "take it or leave it" basis, the services will probably be left. The potential users of a forthcoming inter-institutional service center must be brought into the cooperative venture before it is established, and in such a way that they have a real sense of participation. One organizational approach is to elect a governing board from representatives of the users or potential users and to have the director or executive committee of the service organization report to this board.

The systems alternatives have been configured to meet the computing goals defined in Section 3 for 1975, using the hardware capacities and costs and operating support levels established earlier in this section. Even if money were no object, it would be impossible to meet the goals and to develop the staff and the faculty expertise to use the capacity earlier than 1975.

Finally, we have considered *only* the needs for instructional computing, computer training in the Area Vocational-Technical Schools, and administrative data processing in the collegiate institutions. We have *not* taken into account any involvement of users outside of higher education, such as is planned for the center at Mankato State College. Where there is no excess capacity for such users, it will have to be provided if they are to be accommodated. This may well justify the acquisition of larger facilities than those described here. But then the outside users would pay their share so that the total cost to higher education will not be affected much. Where there is excess capacity by a factor of two or greater, the facility *may* be too large in 1975, unless outside users are brought in. When the excess capacity is less than a factor of two, the facility may be about the right size or it may be too small. If the estimates here are as precise as a factor of two, it is only by luck.

Specification of the Alternative Deployment Configurations

In this section each of the five systems of higher education in Minnesota will be discussed in turn, indicating which alternatives we have chosen for analysis and why. Details of the analysis of each alternative may be found in Appendix H.9; a summary of the results follows discussions of the five systems.

University of Minnesota

In 1975, about 25% of the post-secondary students and almost all of the graduate and advanced training in the state will be concentrated on the Twin Cities campus of the University of Minnesota. It is assumed that the administrative data processing (most of it for all campuses of the University) is confined to a separate, dedicated batch processing facility with a capacity for about one dozen remote query terminals. To our knowledge there are no major universities at which administrative and instruction-research computing have been combined on one machine, and a few where it has been tried and failed. The total amount of computer capacity needed at the University also makes this division sensible.

For instructional computing on the Twin Cities campus, we have made the following assumptions:

1. A configuration of three high-speed input/output stations exists (one on the West Bank, one in the engineering complex, and one elsewhere on the Twin Cities campus) and serves 30% of the instructional computing needs. This requires three high-speed telephone lines.
2. A network of remote-job-entry terminals is connected to the batch processing computer over voice-grade telephone lines and serves 45% of the instructional needs.
3. Interactive time-shared computing is required for about 25% of the computing capacity. These needs are satisfied by local telephone lines to a central time-shared facility which costs about $6,000 per active terminal (or about $150/mo. equivalent lease).

In addition to this instructional capability, the University will need, very approximately, an equal amount of capacity for its research and service computing. Since the cost of this computing will be charged to those activities, it will not be included in the cost estimates here.

At present, about 15% of the work on the Duluth computer is administrative processing which must be carried out locally. This amounts to approximately 35-40% of the total Duluth administrative work load, the remainder being handled in the Twin Cities. It will be assumed that in 1975 60% of the administrative data files are used and maintained locally, as well as in the Twin Cities, and that 50% of the administrative work load is processed in Duluth. Instructional needs will be accommodated by a local batch input/output station (75%) and low-speed teletype terminals (25%). Duluth has had its own medium-sized (Class F) computer for two years. As shown in Tables 4.1-4.3, this campus needs the capacity of such a computer, and will probably outgrow it soon after 1975. The expense of a high-speed communications line to provide this capacity remotely from the Twin Cities would exceed substantially any cost savings resulting from use of a large central computer. By 1975, Duluth should be provided with a voice-grade telephone line to Minneapolis for administrative query terminals and occasional remote entry of large problems on the University's major computer. Excess capacity may be needed to serve users outside the UMD campus, as a regional computing center.

The instructional computing needs at the Morris campus in 1975 can be satisfied by a combination of time-shared and remote-job-entry terminals, each accommodating 50% of the load and served by leased telephone lines. These lines can also service a query terminal to the University's administrative computer. The instructional terminals could be connected to any suitable computer in the state. For instance, tying into a regional center at St. Cloud State College would save a few hundred dollars per month in leased line charges over a connection to the Twin Cities. At the moment, the main University campus seems to be the only source of adequate service.

The computer needs of the University Technical Colleges in Crookston and Waseca most resemble those of junior colleges. In the 1975 deployment schemes, they have been provided with time-shared terminals to the university-managed computer on the same basis as the State Junior Colleges.

The University deployment configurations analyzed are:

U-1: A system with computing facilities in the Twin Cities and Duluth serving all of the University's needs.

U-2: A regionalized system with the two technical colleges and the Morris campus tying into the nearest regional computing center rather than into University facilities.

State Colleges

The State College Board's plan is to have two regional computing center hubs in operation by 1975[5]. The first of these will be implemented at Mankato State College in 1970. It is assumed in one case that the second hub will be in service at St. Cloud State College in 1975, and in another case that only the Mankato computer will be available then. Each of the satellite state colleges have been assumed to possess a Class I computer which functions as a stand-alone computer and a terminal (Table H.7.3). Three of them now have (or have on order) IBM 1130 computers. It is also assumed that the satellite colleges possess Class k terminals for communicating on a remote-job-entry basis with a large computer elsewhere — usually one of the state college hubs.

Although there may be a real demand for time-shared service at the state colleges with satellite computers, it is assumed that they use only batch processing service through remote medium-speed terminals or local high-speed terminals (one high-speed terminal is equivalent to about four medium-speed devices). Replacement of 25% of this capacity with the equivalent number of low-speed terminals for time-sharing would add a relatively small cost to the total. A 14-hour day is available for instructional work by students, with an 8-hour shift for administrative applications at all locations.

The configurations evaluated for the state colleges, then, are as follows:

S-1: Two regional computing center hubs, with the state colleges linked by WATS lines.

S-2: Two regional computing center hubs, with the state colleges linked by telephone lines.

S-3: A single regional computing center hub at Mankato, with leased-line connections to other state colleges.

S-4: A single regional computing center hub at St. Cloud, with leased-line connections to other state colleges.

State Junior Colleges

Administrative data processing has been centralized for the State Junior College system and despite inadequate equipment has provided a very high level of service to its customers (the junior colleges and the State Junior College Board). Because many of the junior colleges are small and geographically remote, it seems most reasonable and economical to maintain centralization of data processing, using United Parcel Service as the communications link for transmitting most of the data. The centralized data processing could be directly under the control of the Junior College Board, or they could lease an appropriate amount of service from some other facility in the Twin Cities. Suggestions on this will be found in Section 5. But it is necessary that the data processing staff be under the State Junior College Board and that they have control of their own data base. In 1975, the Board offices in the Capitol Square Building will need direct access to the computer data base for retrieving information and for carrying out various kinds of statistical studies. For this purpose, they should be able to use the terminal installed by the State College Board. Finally, sometime after 1975 each junior college will need a query terminal for retrieval, checking, and updating information on their own students and budgets. These query terminals are not included in the 1975 configuration.

For instructional computing, many of the junior colleges are so small that one remote-job-entry terminal would far exceed their needs. Furthermore, time-sharing and cooperative access to and development of a common library of instructional programs are effective ways of providing a rather uniform level of instructional computing service to all junior college students.

The three deployments presented in Appendix H.9 for the State Junior College System are therefore:

JA-1: A centralized administrative system, using mail and parcel service for most data communications.

JI-1: A centralized time-shared instructional computing system serving all 20 junior colleges. (The computer facility would be shared with the private colleges and the University.)

JI-2: A regionalized time-shared computing network, with the junior colleges tied into computers located in Duluth, Mankato, St. Cloud, and the Twin Cities.

Private Colleges

Deployment of computer resources to serve the needs of the private colleges is a more speculative projection than in the case of the public institutions, since the colleges are so varied and dispersed. In the Twin Cities there is a group of colleges large enough and strong enough to profitably cooperate and share their resources. This they have already begun to do for both instructional computing and administrative data processing. Several of these colleges also have been using the University's computer facilities, and arrangements are being made to expand this usage substantially. Similar strength, in quality if not in numbers, exists in the Northfield area. The other private colleges are more scattered.

The deployment alternative P-1 shown without costs in Appendix H.9 represents what seems to be the most natural arrangement for the private colleges on a geographical basis. Note that the regional centers planned for Mankato and St. Cloud should have enough capacity to accommodate their neighboring private colleges in 1975. The realization of a deployment like this depends on the readiness of the public institutions to share their resources; the availability of funds, both public and private, to support use of resources; and the response of the individual private institutions. A specific recommendation in the next section deals with the first two conditions.

Area Vocational-Technical Schools

The need for computing capacity in the Area Vocational-Technical Schools has been summarized in Table H.5.3a of Appendix H.5.

Following the projections of the State Department of Education, it has been assumed that in 1975 there will be about thirteen area schools with data processing and accounting programs; three area schools with large (two-year) accounting programs; and eight more with small (one-year) accounting programs. It has been assumed further that the suggested deployments of computing capacity will provide not only enough access, but also excess capacity to serve other regular training programs which may require some exposure to computers: for instance, surveying, drafting, numerical machine control programming, job estimating in carpentry and other trades. Some of the schools also have extensive adult evening programs in accounting and data processing, especially in the larger population centers. It is assumed that the resources serving the day-school population will be adequate for evening students, but the added cost of this extra use has not been included in these deployment estimates.

In Appendix H.9, the following deployment schemes are presented for the area schools:

> V-1: A single central computing facility serving all area schools needing service, via remote-job-entry terminals and WATS lines. This alternative is the one suggested without analysis or documentation in the 1969 ARIES Report on data processing in the vocational schools. This alternative has been analyzed in terms of business mini-computers (Class i terminals) at those locations with data processing or large two-year accounting programs, and Class k remote-job-entry terminals at other locations.
>
> V-2: Service through remote terminals from regional computing centers located in the Twin Cities, Duluth, St. Cloud, and Mankato.
>
> V-3: Service from a combination of small (Class H) computers at some of the area schools already processing them; business mini-computer terminals at other schools with data processing and large two-year accounting programs; and simple remote-job-entry terminals (Class k) at schools with accounting programs.

A Fully Regionalized Deployment for Higher Education

Several of the alternatives examined for each of the systems of higher education have involved regional centers providing computing service. This last deployment configuration, R-1, combines each of the regional configurations U-2, S-2, JI-2, and V-2 to summarize the total networking and cost implications of a fully regionalized system for the public institutions. This kind of a system should not be considered until at least one regional center has demonstrated that it can meet the goals of instructional computing for many institutions in a way that is reasonably satisfactory to users of the service provided.

Summary of Results for the Deployment Alternatives

The costs associated with each of the configurations described in the previous section and analyzed in Appendix H.9 are summarized in Table 4.5. These rough cost estimates are based on July 1970 projections of enrollments in 1975 and are one factor considered in arriving at the recommendations in the next section of this report.

In interpreting and comparing the costs in Table 4.5 with other estimates in this report, it is important to keep a number of facts in mind.

- Only instructional computing in the public institutions, computer training in the vocational schools, and administrative data processing in the public collegiate institutions have been included. Special-purpose training and laboratory computers, public service and research computing, library automation, and computer-assisted instruction development have been excluded.
- Staff and operating support costs have been assumed to equal monthly hardware costs for all kinds of computing except in the vocational-technical schools. As remarked elsewhere, the 1:1 ratio is appropriate for instructional computing, while a 2:1 operating-to-hardware ratio is

Table 4.5. Summary of Monthly Equivalent Lease Costs Associated with Each of the Deployment Configurations Analyzed (1970 Dollars)

Configuration	and Description	Computer Systems	Mass Storage	Terminals	Communications	Operations and Staff(d)	Total
U-1	Intra-University System	109,750	5,848	32,400	12,088	160,086	321,072
U-2	Regionalized University System	114,350(a)	5,848	32,400	11,830	164,428	328,856
S-1	State College System with Two Hubs, INWATS	60,000	9,114	9,600	8,380	87,094	174,188
S-2	State College System with Two Hubs, Leased Lines	60,000	9,114	9,600	7,240	85,954	171,908
S-3	State College System with One Hub at Mankato	60,500	9,114	12,800	11,564	93,978	187,956
S-4	State College System with One Hub at St. Cloud	60,500	9,114	12,800	10,996	93,440	186,880
JA-1	Central Administration System for Junior Colleges	10,000	1,333	–	–	11,333	22,667
JI-1	Central Time-Sharing for Junior Colleges	12,300	(b)	6,150	4,849	23,299	46,598
JI-2	Junior College Time-Sharing Using Regional Centers	13,650*	(b)	6,150	4,696	24,496	48,992
P-1	Private Colleges(c)						
V-1	Area Vocational-Technical Schools Using Central Computer	12,800	(b)	48,100	18,938	(d)	79,838
V-2	Area Vocational-Technical Schools Using Regional Centers	7,900	(b)	48,100	8,520	(d)	64,520
V-3	Area Vocational-Technical Schools Using Small Computers and Terminals	14,500	(b)	43,100	7,718	(d)	65,318
R-1	Fully Regionalized System	195,900	14,962	96,250	31,366	274,878	613,356

(a) These costs are based on expected average utilization rather than peak load capacity.

(b) Mass storage for instructional systems is included in the cost of the computer systems.

(c) Costs have not been estimated for the private colleges as a system. The computing and terminal capacities needed for individual colleges can be estimated from Tables 4.1 – 4.3. Communications costs will be quite low, because all private colleges are near regional centers (except Concordia, which could ride an unused channel on one of Moorhead's lines to St. Cloud).

(d) Staff and operations cost is assumed to equal the sum of the other costs, except for the Area Vocational-Technical Schools. AVTS computing facilities are staffed by regular faculty members as part of their teaching duties, and by students as part of their instructional program, not by specially-hired operators, programmers, and managers, as is the case in the other systems.

more suitable for administrative processing, and about 2:3 for small dedicated time-shared computers. Both of these other applications are relatively small, and the overall picture has not been changed greatly.

- Costs quoted for computers are based on market value, *not* on what the institution or the State actually paid. For instance, the University paid about 55% of market value for its Class B computer, of which 45% came from a federal grant (see Appendix H.4), and Mankato is planning to lease its Class D machine at about $20,000/month rather than the $40,000 class rate in Table H.7.1. The differences arise from variations in costs of computers in the same class, and from discounts and grants by the manufacturer. The operating support for these facilities, however, should be based on market value rather than discounts.

A close examination of Table 4.5 permits several other interesting observations.

- Regionalization of computer services does not appear to result in large savings for the University or the Junior College System; the decrease in communication line cost is small because of the geographical distribution of institutions and is partly offset by increased cost of computer services from regional centers, rather than from dedicated Class Z time-shared computers or from the University's super-efficient Class B computer. There do seem to be savings for a two-hub state college system as opposed to a single hub, for a regionalized vocational-technical school network a centralized system, and for the University Technical College in Crookston and Waseca connected to a junior college network rather than to other computers of the University (see the R-1 configuration in Appendix H.9). These conclusions, however, *could* be changed by a number of developments: for instance, availability of GSA telephone lines, implementation of a statewide communications network, regionalization not just within higher education but involving other public agencies, dispersal rather than centralization of Class Z time-shared computers. With the exceptions mentioned and on the basis of presently available communications facilities, then, it would seem that the matter of regionalization vs. centralization could be settled on the basis of educational effectiveness rather than cost.
- If the Pierce Report goals for adequate computing are met in 1975, then the cost per student of computing at the University will be about 1.7 times that in the state colleges (see Table 5.6 in the next section). This reflects primarily the high cost of graduate and post-graduate professional training in terms of computing, as well as all of the other resources consumed by this form of advanced education.
- On a per-student basis, computing in the state colleges, junior colleges, and vocational-technical schools costs about the same. It would be noticeably less in the junior colleges except that the separate administrative computer there is rather more expensive than administrative computing in the state colleges. When it is recalled that only about 10% of the students enrolled in vocational-technical schools are in data processing or accounting courses, the cost per student who actually uses the computer becomes ten times the average cost per student in the collegiate institutions. This matter will be discussed in greater detail in Section 5.
- It is apparent from these considerations that the State Junior College System can reduce its administrative costs either by utilizing a large computer facility outside the system, or by selling its excess capacity to other users in the state or in higher education.

Several of these observations will be referred to or elaborated upon in Section 5, in terms of the more complete computing cost projections there.

5. RECOMMENDATIONS AND DEVELOPMENT SCHEDULES

This final section of the report on higher education contains:

a) A series of recommendations for actions or policies — in general, for each of the five systems of higher education, and for the Higher Education Coordinating Commission;

b) A rather specific five-year schedule for developing computing capability in Minnesota higher education, complete with order-of-magnitude cost estimates;

c) A more general indication of developments during the second five-year period, 1975-1980;

d) Some comparative information on other cost figures in higher education to place the cost estimates from (b) in perspective; and

e) Suggestions for priorities and planning to use the funds which may become available.

In a certain sense, the section could be considered a "Master Plan" for computers in Minnesota higher education. The recommendations and funding estimates, however, must be thought of as guidelines; they must not be used as rigid, specific plans. The scope and time available to complete the study have not been sufficient to develop specific, detailed implementation plans, which in any case are the responsibility of the institutions and systems themselves. What the report attempts to do is to estimate the computing capacity required for many of the major functions and areas of higher education in Minnesota, to assess the approximate cost of providing this capacity, to recommend alternatives for its deployment throughout the state, and to discuss some of the problems and organizational structures associated with implementing the recommendations.

The scope of this part of the study excluded even a general survey of the computer needs of elementary and secondary education. Even though some post-secondary institutions plan to provide computer services to schools and other outside agencies, the capacity and cost to provide these services have not been taken into account. Any such plans will naturally require capacity in excess of the needs of higher education. If this excess capacity has not been included in our estimates, then it will have to be provided. If it has been included, then it will be the responsibility of those managing the facility to insure that, in the long run, the excess capacity is utilized effectively, and that its incremental cost to higher education is recovered.

RECOMMENDATIONS FOR MINNESOTA HIGHER EDUCATION

General Recommendations

1. The objectives of the 1967 report of the President's Science Advisory Committee, *Computers in Higher Education*[1] should be met in Minnesota within about five years. This report, commonly referred to as the *Pierce Report* after the chairman of the Committee, called for a nationwide program to bring all college and university computer facilities in the United States up to the level of those best equipped in 1967. Although the *Pierce Report* based its recommendations on the use of time-shared computing to meet all of the instructional needs of higher education, a combination of batch processing and time-shared computing appears more desirable. This is reflected in Section 3 and in the budget recommendations of Section 5 of this report.

2. It is neither necessary nor desirable to establish full-scale educational programs in Computer Science or Data Processing at all public institutions of higher education.

   At this time, it appears that the needs of the state will be satisfied by the following well-supported programs:

   a) At the University, undergraduate, graduate, and research programs in the Department of Computer, Information, and Control Sciences, plus a strong component of training and research in data processing in the areas of business, educational, and public administration.

   b) In the state colleges, about two baccalaureate degree programs with majors in computer science, plus incorporation of computer and data processing training into the programs of all students in science and in business educational, and public administration.

   c) One junior college program in data processing, using the administrative computer at Lakewood State Junior College. Some other junior colleges may be able to share in data processing programs at nearby area vocational-technical schools.

   d) Six to eight full data processing curricula at area vocational-technical schools. (The use of data processing and computing in other fields, such as accounting, drafting, engineering technology, etc., must be supported in addition.)

Computer installations serving the instruction, training, and administrative needs of higher education must be operated on a service-oriented basis. Where these three functions are combined on one computer, instruction and training should normally be scheduled during the school day, with administrative applications handled at other times.

Regional or statewide computer services which involve several institutions or systems must be organized to provide the users with a meaningful voice in establishing priorities and controlling the level of services provided.

It is clear from conversations with educators and others throughout the state, that regional computing centers and other inter-institutional arrangements will fail utterly if this voice is not provided. The beginning of this process of providing a meaningful policy voice is the development of a charter or statement of mission for the inter-institutional center by the management of the center *and* prospective users.

5. Support is recommended for research and development activities associated with information services and depending on accurate, continuously updated data bases. Such work is being carried out by several groups at the University of Minnesota, in cooperation with various state agencies. This work should receive separate funding – supplemental to the regular operating budgets of the University and of the state agencies involved. Examples of these activities are: the Minnesota Analysis and Planning System (MAPS), the Rapid Analysis Fiscal Tool System (RAFTS), the Land Usage System being developed by the Center for Urban and Regional Affairs and the State Department of Administration, and the Information Management System being developed for the Pollution Control Agency by the Hybrid Laboratory.

   The Department of Administration, the University, and the appropriate state agencies should develop a program which includes: (a) a research and development budget for the above systems for presentation to the 1971 Legislature, and (b) a program of orderly transfer of responsibilities to state agencies and departments as the programs move from the developmental to the operational stage.

   Appropriations should be made to the appropriate state agencies and contracts should be jointly developed by the University and the agencies for which the University carries out the research and development activities.

Information services planned around archival and bibliographic data bases should be managed by the Statewide Library System mentioned in Recommendation 29.

6. The two systems of higher education which have a defined mission in research and graduate training are the University of Minnesota and, to a lesser extent, the state colleges. Research activities in general are funded by a combination of institutional resources and outside grants and contracts. Research computing is and should be supported in the same way so there is no need for direct funding of such activities as far as these recommendations are concerned. It is necessary, however, that the University have available to it the kind of computer capacity and facilities required for scientific and other research work, and we recommend the maintenance and support of this capacity. If the State Colleges possess enough computing power to accommodate their instructional needs, they should have little difficulty in providing enough excess time to take care of most of their research needs. Certain large computing or data processing problems at the State Colleges may be more economically processed at the University's computer center or eventually at one of the other regional centers. To handle problem interchanges of this kind is one reason for Recommendation 25 that common communications interfaces be maintained between all computers in the state.

7. During the course of this study, it became apparent that there is a serious need for school personnel trained in both educational administration and information and computer technology, as well as for more teachers of business, mathematics, and the natural and social sciences with training in the uses and applications of computers. These needs could be met by adding requirements to existing degree programs and certification standards in order to encourage pre-service training in computer science for teachers and educational administrators. It is recommended that the State Department of Education and institutions granting education degrees adopt such requirements. The major problem in implementing modern information systems and computer instruction technology in local school districts is a lack of people trained in these fields.

Recommendations for Each of the Five Systems of Higher Education

The University of Minnesota

8. The University has already established and is implementing plans to make available to other colleges remote service on its CDC 6600 computer. This external service will be provided within the state on the same cost basis applied to internal users. Funds should be provided for:
   a) Communications controllers and other central site expansion to meet the demand; and
   b) Terminal and communications hardware for colleges within and outside the University which need access to the 6600.

9. The University needs a time-sharing capability to satisfy its own needs; these are currently being met by commercial services. A statewide instructional time-shared computer system should be acquired and established under University management, with sufficient additional capacity to serve, at least for an interim period, the instructional needs of the State Junior College System and the time-sharing needs of nearby private colleges.

10. The University, as the major research institution in the state, should undertake research and development on the applications of CAI, CMI (Computer-Assisted and Computer-Managed Instruction), and other

aspects of learning psychology and technology to the problems of mass higher education. There are potentially large economies and productivity increases in education which may be achieved by these new technologies. However, such applications should be undertaken initially on a research basis because of the high development cost and inherent risk. Appropriate faculty of other state institutions should be involved in these developments so that they may be extended easily for statewide use if proven successful. The Center for Research in Human Learning (CRHL) at the University is concerned with a basic understanding of the teaching-learning process and the application of this knowledge to practical problems of education through CAI, CMI, and other appropriate media. Significant development work is also under way at both Southwest Minnesota State College and Macalester College on the management of instruction by computer. It may be appropriate for the CRHL to play a coordinating role for these activities. But all of them will require some technical services and support.

It is recommended that a statewide center be established and funded to provide computer services and other technical support to development activities in CAI and CMI at the Center for Research in Human Learning *and* at similar centers throughout the State of Minnesota. This Center would also coordinate CAI programs and aid in their transition from research and development to operational or "production" status.

11. Computers have become important instruments in non-computational laboratory instruction, particularly in professional programs in computer science and in engineering. Establishing laboratory computer systems for certain of the University's professional programs in engineering and computer science constitutes an important component for the development of instructional computing in Minnesota. It is recommended that the installation of these laboratory computers at the University be funded.

12. Because of its size, the administrative data processing activity at the University is more complex than that in any of the other systems studied. It is recommended that the University continue to implement an administrative data processing system with complete and well-maintained data bases, as suggested in Section 4. This would prepare a solid foundation for the development of effective management information and program budgeting systems. A study of the University's needs in this area is currently being carried out by Cresap, McCormick and Paget, Inc.

13. Adequate computer services should be supplied to the University's coordinate campuses in the following ways:

   a) **Duluth.** Its size and distance from other large computer facilities make it uneconomical to supply the Duluth campus with the service it needs over telephone lines. It is recommended, therefore, that the computer capacity at UMD be expanded to keep pace with the level of service required by its students. If after 1975 the regional computer center concept has proven successful, then UMD should be considered as a center for northeastern Minnesota.

   b) **Morris.** To meet its immediate needs, the Morris campus should be provided with a remote-job-entry terminal to the University 6600. As this campus grows, its capacity may be expanded either by upgrading the terminal to one with some independent computing capability or by providing some terminals to a time-shared computer facility.

   c) **Technical Colleges at Crookston and Waseca.** The computer needs estimated for these technical colleges most resemble those of a typical junior college. The most effective and economical way to provide them with computer service is via the same mechanism established for the junior colleges; vis., a tie-in to an instructional time-shared computer facility.

The State College System

This recommendation supports, in general, the plan of the State College Board as described in the January 20, 1970 Position Paper by Dr. John E. Haugo[5]. The plan calls for the development of a network of regional computer centers, providing administrative data processing and instructional computing for the colleges, and serving other state and educational (school district) users as well. The first of these regional centers, the southern hub at Mankato State College, is presently in the process of being established. More specific recommendations are as follows:

14. Planning for the northern Regional Computer Center at St. Cloud State College should build on the experience at Mankato, and should proceed in two phases: (1) for installation in 1973 a small-to-medium-sized computer servicing a limited number of remote terminals and operating both independently and as a satellite to the Mankato Regional Center; and (2) a larger independent computer system similar to the one at Mankato, to be installed in 1975. Funding for these phases will be required from the 1971 and 1973 legislative sessions, respectively. The State College Board must request for 1971-72 sufficient funds to develop the staff necessary to plan this center in detail and later to operate it.

15. As soon as possible (i.e., 1970-71), each one of the state colleges excepting Mankato should be provided with remote terminal facilities capable of interfacing with the Mankato Regional Center, with the 6600 at the University of Minnesota, and with any other appropriate facility. The colleges should also be provided with funds for approximately one-half hour per month of computer time and for telephone connections to begin acquiring experience in using large computers, as well as to provide needed immediate services for their students and administration.

16. It is important that the State determine whether a regional computer center serving many different users, as is being established at Mankato State College, is viable. Therefore, it is recommended that the Regional Computer Centers at Mankato and St. Cloud State Colleges be supported in their first few years of operation at a level sufficient to insure that their success or failure results from the level of service they provide rather than from inadequate funding. Users of Regional Center services outside of higher education should be expected to pay for services received; the income should be returned to the State in proportion to the level at which the regional centers are funded. Likewise, since the funding is for instructional purposes, the State Colleges themselves should be expected to pay the regional centers for administrative data processing carried out on these facilities.

17. The development from a two-hub network to a system with regional centers at each of the six state colleges should proceed only after a careful evaluation of the experience during the first five-year period, particularly the experience of users outside higher education. Plans for further expansion of the system to meet the computing needs of higher education should be revised on the basis of this experience.

The State Junior College System

Plans for this system are an extension of current activities and call for separate, centralized facilities — one for administrative data processing and one for instructional computing.

18. For the immediate future, the State Junior College System should continue to have access to an instructional computing system which will provide service to low-speed (teletype) time-shared terminals at each of

the junior colleges, using telephone lines. This service will need to expand from 18 terminals and three computer ports in 1970-71 to about 100 computer ports in 1980-81. It is recommended that the staging of this expansion proceed as follows:

a) 1970. Service from a commercial vendor of time-shared computing (the existing situation).

b) 1971. Service from a time-shared computer dedicated to higher education, and managed by the University of Minnesota or other appropriate agent.

c) 1974-1976. By this time, development in the state should have proceeded to a point at which one of the following three alternative expansion plans can be followed:

   (1) Further development and expansion of the University-managed service. Possibly this would develop into a higher education computer facility independent of the University or other original managing agent with computers at several different locations.

   (2) Establishment of a central instructional computer serving the Junior College System.

   (3) Decentralization of the Junior College System by tie-ins of individual colleges to regional centers. This alternative should *not* be followed unless and until two conditions are met: the regional centers must be capable of providing an adequate quality and quantity of service to the junior colleges they serve; and there must be significant cost savings and/or needed improvements in service to justify and offset the additional problems of articulation and coordination which accompany decentralization of this service within an otherwise centralized system.

19. The centralized administrative data processing system has worked effectively and economically in the past. We recommend continuation of centralized ADP in the Junior College System under the following terms:

a) They should be provided with third-generation data processing facilities, including an efficient COBOL system and increased and expandable disk storage. These facilities could consist of a small-to-medium sized computer system under the control of the State Junior College Board. In this case, the excess computer capacity during off-peak hours should be made available on a reasonable basis to other educational institutions and governmental agencies. Another alternative would be for the junior college data processing staff to work on a large facility controlled by another agency of higher education or state government. The conditions under which this second alternative would be feasible are that the Junior College Board retain its own data processing staff (programmers and system analysts, but not including computer operators) in its employ and under its control; that priority access to the large computer facility be available at least one shift per day and more at peak load periods; and that significant cost savings to the state exist to offset the problems of multiple staffs using a single facility.

b) The data processing staff of the Junior College System should undertake the design of an inexpensive remote inquiry system for the use of administrators at the individual colleges. As programs expand, and particularly at the larger colleges, administrators will encounter needs for quicker access to limited volumes of information on specific students, budget accounts, etc. It should be possible to meet these needs inexpensively through an automatic file query system perhaps using the same low-speed terminals employed for instruction. Development and experimental implementation of this system should begin late in the 1970-75 period, with full statewide implementation occurring during the second five-year period, 1976-80. However, the bulk of the junior college administrative needs can be met effectively and economically as at present, by using delivery services for mass data communications.

Area Vocational-Technical Schools

Plans for these schools are somewhat dependent on the outcome of experiments still under way. Currently three schools have small-scale computers for their data processing and related curricula. Others will have remote-job-entry terminals and at least one will have a mini-computer as a terminal. The planning alternatives thus would appear to be as follows:

a) The centralized system proposed in the ARIES report to the State Department of Education. This alternative is not recommended because it appears to be more expensive than other deployments (see Section 4).

b) A regionalized system whereby those AVTS with computing requirements would have remote batch terminals connected to regional computer centers. This approach should be tried by several AVTS in the very near future in order to determine the viability of this mode of operation for vocational training.

c) Stand-alone computers or mini-computers used as terminals at those AVTS with data processing curricula. Business mini-computers at those schools having very large two-year accounting programs; these mini-computers could also serve as terminals connected to other computers. More limited medium-speed remote-job-entry terminals could be provided at schools with one-year accounting programs.

20. It is recommended that over the next five years alternatives (b) and (c) be implemented at various AVTS to gain experience with their viability for vocational education. This implies the continued support of small (Class G) computers at Alexandria, Hibbing, and perhaps one other location; the provision of six to fourteen business mini-computer terminals (Class i, Table H.7.4) and seven to fourteen simple remote-job-entry terminals (Class k, Table H.7.4), plus the costs of communications and computer service from a state college, the university, or some other public or private agency. At least one of the business mini-computers and one of the simpler terminals should be connected *as soon as possible* to the Mankato regional computer center, so that experience in working with an organization of this kind can be acquired. It is hoped that several of the terminals can work into college or University-based facilities during the five-year period. By the end of this period, it will be possible to make an informed decision on the future direction of facilities for vocational training.

This recommendation does not include the requirements which would be imposed on AVTS computer systems by services to local school districts for either administrative data processing or instructional computing. The instructional computing requirements considered here were primarily those for data processing and other business and trades education within AVTS curricula. Other functions and services would require computer capability in addition to that recommended. (See Section 2 in the Local Government portion of this overall report.)

Private Colleges

The analysis performed in this study has shown that the computer facilities in Minnesota private colleges fall short of their needs. The private colleges represent a valuable educational resource, and it is in the interest of the State of Minnesota to encourage the development of computer facilities and instructional programs in them. The regional centers recommend in this report can surely assist in this.

To support their plans for individual and cooperative uses of computer facilities, the following kinds of assistance to the private colleges are recommended.

21. Technical assistance and advice should be provided by the staffs of the large computer installations in higher education and State government to help the private colleges develop communications interfaces between their terminal and computer hardware and those of the public institutions.

22. Computer systems in the public institutions should provide services to private colleges at cost. It is specifically recommended that the regional computer centers in higher education provide remote-job-entry service to private colleges with suitable terminals, and that a time-shared computer system used by the University and junior colleges be made available to private colleges who wish to use it.

23. Because of the importance of encouraging the development of computer facilities in private colleges it is proposed that, within constitutional constraints, the State aid development of computing capacity in the private colleges by funding the establishment of regional centers and regional computer communications networks; and by providing grants to the private college to subsidize their use of these services. It is recommended that these subsidy grants build up to cover approximately half the cost of the computer services required to meet the educational needs of the private colleges.

Recommendations Addressed to the Higher Education Coordinating Commission

24. To carry out its mission to:

> continuously study and analyze all phases and aspects of higher education, both public and private, and develop necessary plans and programs to meet present and future needs of the people of the State in respect thereto, and continuously engage in long-range planning of the needs of higher education and, if necessary, cooperatively engage in such planning with neighboring states and agencies of the Federal government (Minnesota Statutes 136A),

the Minnesota Higher Education Coordinating Commission requires access to machine readable data bases and facilities for processing various kinds of educational data. To honor the requirements of security and privacy, the data bases of the individual systems and institutions should be constructed so that the Commission can gain access to the information needed to carry out its legislative mandates. Similarly, the Commission must be provided with adequate budget support to pay for the data processing needed. At the moment, approximately $17,000/year is being spent on data processing of all kinds but primarily on the Higher Education Facilities Inventory and the Scholarship Program. As these activities are expanded and others added, the Commission must be provided with the additional funding to support the data processing services required by the expansion. With no expansion, a funding level of $20,000/year for data processing would appear to be minimal; the actual needs of the Commission must be assessed by its staff in terms of the programs they are required to support.

The following specific actions are recommended to provide the Higher Education Coordinating Commission with the data processing and information support it needs:

a) Establishment and funding of a full-time staff position to be filled by an analyst with appropriate and extensive training and experience. Although this person would consult with other staff members on applications programs, his primary functions would include analyzing the program needs of the Commission for information and data processing, managing the services required to fill these needs, and advising the Executive Director on program and budget requirements for information and data processing.

b) Access to batch processing services and appropriate data bases at the Computer Services Division, the University, the State

Junior College administrative computer, as appropriate to specific needs. Remote access to these computers and associated data bases may be obtained through the remote terminal of the State College Board, located in the Capitol Square Building. A significant fraction of the use of this terminal may eventually come from the Commission staff.

25. To further enhance the availability and usefulness of information to the Higher Education Coordinating Commission to meet the needs for information on higher education of the legislature, other units of government, and the Federal government, it is important that the data bases of each institution or system either be maintained in a standard format using a standard set of definitions, or that translation programs be provided by the institutions or systems as required to insure comparability of data, both within the state and with other states. It is recommended that the Commission establish a mechanism, involving representatives of the higher education systems and the Commission staff, to develop coordination and security standards for system data bases and application programs. It is expected that this group will maintain cognizance of developing national standards, such as those of the Planning and Management Systems Division of the Western Interstate Commission for Higher Education (WICHE), and will insure that Minnesota is compatible with them when they become nationally accepted.

26. To increase the availability and variety of instructional computer services and to further enhance the availability of information on higher education, a standard communications interface should be established between terminals and computers in all state agencies and institutions of higher education. It is recommended that the Higher Education Coordinating Commission establish a technical committee, perhaps reporting to the Computer Advisory Committee, to develop the specifications, implementation standards, and coordination mechanisms to create and maintain compatible communications interfaces. This effort should be coordinated with the development of similar standards for State agencies and local governments by having the State Communications Engineer sit on this committee. Since the needs for coordinating computer communications in higher education are immediate, this committee should be formed early in the fall of 1970. It may be possible later on to form a single data communications standards committee serving all governmental agencies, including higher education.

27. The Minnesota and North Dakota Higher Education Commissions are in contact concerning exchanges of students and other topics. Because there are geographical affinities between eastern North Dakota and northwestern Minnesota, it is recommended that the Minnesota Higher Education Coordinating Commission explore with its North Dakota counterpart arrangements for sharing in the use of computer resources. A logical first step in this direction would be for Minnesota to invite a technical representative from North Dakota to participate in the work of the Communication Standards Technical Committee. It is the work of this committee which will be instrumental in the sharing of computer resources both within and without the State.

28. A great need exists for in-service computer and information systems training for educational administrators and secordary mathematics and science teachers. In-service training opportunities should be provided throughout the state through the continuing education services of the University, the State Colleges, and the school districts. Many excellent in-service programs have been offered through these systems, but they seem to be offered with little consultation among the institutions with missions involving this

kind of public service and with little geographical coordination. To provide the needed channels of communication and coordination, we recommend the establishment by the Commission of an *ad hoc* Committee on the Coordination and Standards of Pre-Service and In-Service Training Programs in Computing and Data Processing.

29. The Minnesota Higher Education Coordinating Commission, or some other appropriate agency, should act to initiate the planning for and development of a Statewide Automated Library System. The organization envisioned for this System will probably be managed by an Executive Officer acting under the direction of a Policy Board representing the several kinds of libraries in the state and advised on technical matters by a Technical Advisory Board. It is recommended that the Commission establish these boards immediately, and charge them with preparing for the 1971 Legislature a detailed implementation plan based on the work of the University Library Systems Staff and the Becker and Hayes evaluation and recommendations (Appendix H.2). This plan must include a specific designation of the organizational structure and staffing required to administer development of a Statewide Automated Library System. Being an organization involving a large geographical area (the entire state) and a wide variety of libraries with differing missions, the concerns expressed under Recommendation 4 above are relevant here.

30. The effective use of computers in higher education will continue to require developmental efforts by specialists versed in higher education and computer technology. The special appropriation of $300,000 by the 1969 Legislature has been most effective in stimulating the development of many useful computer applications and services in higher education. It is recommended that:

    a) The computer Advisory Committee of the higher Education Coordinating Commission prepare for the 1971 Legislature a report summarizing and evaluating what has been accomplished with these funds over the time they have been available; and

    b) Limited and special developmental efforts continue to be funded through an appropriation to the Commission in a manner similar to the interim funding of 1969-71, and at a similar or slightly expanded level.

To distribute these funds in the most effective manner, the Commission should establish a review panel to evaluate proposals and recommend funding, as was done with the special appropriation for the 1969-71 biennium.

The links between institutions and systems implied by the preceding recommendations will require a high degree of coordination in developing the facilities and organizations required to achieve an effective and efficient educational computing capacity in the state. To bring about this coordination, the Minnesota Higher Education Coordinating Commission has based its approval of this Report on the following statements of general policy:

1. All institutions and systems of higher education, prior to the development of their legislative requests, shall identify to the Higher Education Coordinating Commission their plans for computing for both facilities and for operating costs. These plans should provide detailed information on budgeted costs and program justification. The Commission shall review these proposals to determine how these plans are coordinated with the Master Plan — how they approximate the goals and where they deviate from them. The Commission shall prepare a Summary Report for each Legislature on the progress that has been made toward achieving the goals of the Master Plan. This Summary Report also shall include recommendations regarding the requests which are being submitted by the institutions and systems, and by the Commission itself.

2. For on-going or operational computing activities, the responsibility for planning and for preparing legislative requests shall rest with the individual systems of higher education. Funding will be appropriated to the individual systems.

3. The Computers and Information Systems in Higher Education Report identifies four programmatic areas of a developmental nature. These are:

   (a) a development center for Computer-Assisted and Computer-Managed Instruction.

   (b) a State-wide automated library system.

   (c) a program of grants for projects in research and in development, within each biennium, related to computing in higher education (continuation of an existing program).

   (d) grants to private colleges in support of their computing activities.

   For these four developmental activities, the responsibility for planning shall rest with the Commission. For grants programs (c and d above) the Commission will also prepare the legislative requests and receive the appropriations. For activities which involve both new facilities and operating support (a and b above), the legislative requests will be prepared jointly by the Commission and those individual systems which plan to make use of the facilities. Appropriations for facilities will be made to the Commission; appropriations for operating costs associated with the developmental activities themselves will be made to the appropriate system or agency, including the Commission itself. The Commission may assign management responsibility for the facility to another board or agency.

4. Adjustments in implementation plans presented to the legislature in accordance with procedures outlined in Number 1 above shall be subject to review by the Commission.

5. The Commission proposes to review periodically the effectiveness of the policies being adopted here and to make or recommend such changes as it deems advisable.

Adopted by the Executive Committee
of the Minnesota Higher Education
Coordinating Commission
September 17, 1970

A TIME-PHASED FIVE-YEAR PLAN

Figure 5.1 displays a long-range plan for computers and information systems in public and private higher education in Minnesota. Planning for the first five years is naturally much more specific and detailed in this chart than for the second five years. The plan is further detailed as an estimated budget in Tables 5.1 through 5.5. All cost projections, in these and other tables in this report, are based on uninflated 1970 dollars, and on enrollment projections for 1974 or 1975 obtained during the spring and early summer of 1970 from the systems of higher education or through the Higher Education Coordinating Commission. If significant monetary inflation occurs, or if the enrollment goals or projections of institutions change from those represented in Appendix H.10, then appropriate adjustments must be made in the budget projections of Tables 5.1 through 5.5.

Table 5.1 lists existing computing facilities by function and includes estimates of equivalent net purchase price; equivalent annual lease price (estimated at 27% of the purchase price); and recommended annual support budgets which are estimated here as well as in Tables 5.4 and 5.5 as follows:

For administrative data processing facilities, 2.0 times the annual lease including maintenance, or 60% of purchase price per year.

For facilities combining administrative and education computing, 1.5 times the annual lease including maintenance (45% of purchase price per year).

For instructional computing facilities, 1.0 times the annual lease including maintenance (30% of purchase price per year).

For time-sharing central computer facilities, 0.6 times the annual lease including maintenance.

- For remote terminals, 0.5 times annual lease (medium-speed) or 0.1 times annual lease (low-speed or time-sharing), both including maintenance.

The actual support budgets for existing facilities are also given if they are known. Table 5.2 gives a proposed funding schedule for computing equipment for 1971-1975 on a purchase basis. This funding schedule for the next two legislative biennia estimates the costs of the recommendations in the previous section. These recommendations encourage the development of major regional computer centers at the University, at Mankato State College, at St. Cloud State College, and eventually at Duluth. Costs of equipment for a time-sharing system and the vocational schools are also significant. The equipment cost listed for the Statewide Library Plan would be the computer to be acquired during the third phase of that plan. Table 5.3 presents the same information as Table 5.2 but on a lease basis rather than a purchase basis. The factor 0.27 was used in computing lease equivalents because maintenance was assumed to be a part of operating costs and is included in Tables 5.4 and 5.5. The spending levels for facilities do not show a notable increase over 1964-1969 levels during the first year of the plan (1970-1971) since funding for that year has already been allocated, but they do increase markedly beginning with the second year (see Figure 5.2).

Operating costs corresponding to the new equipment are estimated in Table 5.4 as an incremental budget forecast. The same information is given in Table 5.5 in the form of total rather than incremental yearly costs. These budgets for equipment and operations should not be interpreted as refined estimates of planned expenditures, but they do serve to evaluate the costs of the fundamental recommendations, i.e., attempting to meet *Pierce Report* goals by 1975[1].

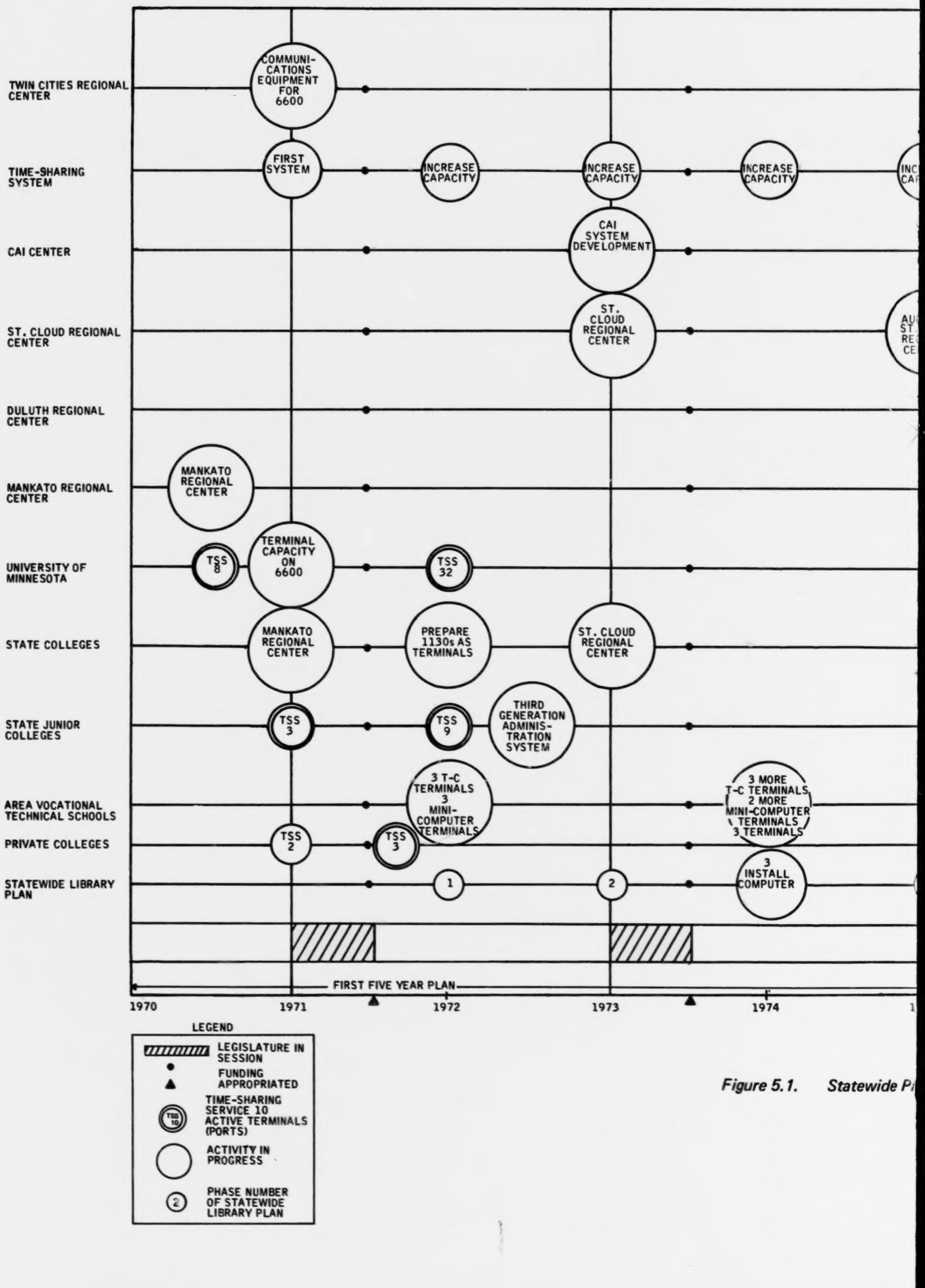
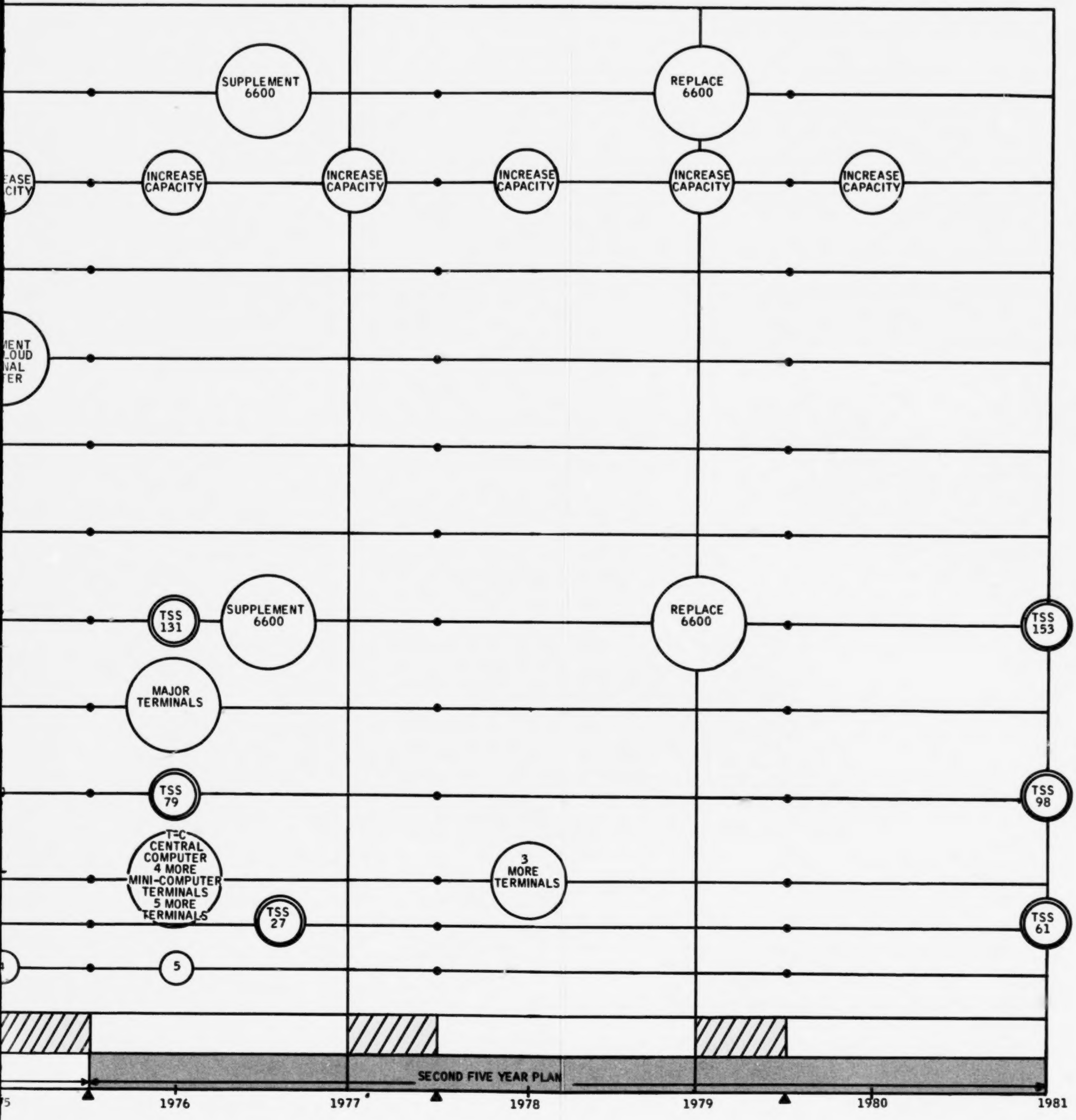


Figure 5.1. *Statewide Pl*


SUPPLEMENT 6600
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REPLACE 6600
TSS 153
MAJOR TERMINALS
TSS 79
TSS 98
T-C CENTRAL COMPUTER 4 MORE MINI-COMPUTER TERMINALS 5 MORE TERMINALS
3 MORE TERMINALS
TSS 27
TSS 61
5
SECOND FIVE YEAR PLAN
75
1976
1977
1978
1979
1980
1981

for Computers in Higher Education

During the latter stages of preparing this report, it became apparent that two of the cost and capacity standards used in this section and in Section 4 were no longer accurate:

- The standard medium-speed remote job entry terminal (Class k in Table H.7.4) will not operate at 300 lines or cards per minute, but more nearly at 150 lines or cards per minute. The one terminal which performs at the higher rate and sells near the $32,000 purchase cost of a Class k terminal has been removed from production (except in Japan), and is no longer readily available. Correcting the cost estimates in Sections 4 and 5 to account for this would require a doubling of the number of medium-speed terminals, or stepping up their cost and capacity to Class j, either of which would approximately double the estimated cost. In addition, extra communication line capacity would be needed.
- The Bell Telephone System has just announced an originate-only low-speed modem, which reduces the lease cost of a teletype terminal (Class m) from $75 to $62 – about 17%.

The numbers and costs of terminals estimated here and in Section 4 have not been changed to reflect these conditions because of the time pressure on completion of this report and also for three more valid reasons: (1) the increase in costs associated with Tables 5.1-5.5 and the summary table under Plans in Perspective range from about 2% of the total in 1971-72 to 7% in 1974-75, well within the accuracy which can be claimed for any of these estimates; (2) changes in technology and pricing are most likely to be substantially greater than this by 1975, invalidating even these corrections to the cost estimates; and (3) it is possible, and even educationally desirable in some cases, to use one high-speed remote terminal to replace five or six medium-speed terminals when communication line costs are not a significant factor, thus reducing terminal costs somewhat. It is most important that those using this report for planning and evaluation make note of these current inaccuracies, so that discrepancies of a factor of two in the terminal numbers and costs quoted in Tables 4.1-4.3, 4.6, 5.2, and 5.3 will not come as a complete surprise. These changes also illustrate the fact that estimates of the kind developed in this report must be consistently updated and modified – they are never precise. However, the changes are a small fraction of total costs, and except for the effects of inflation, we would expect them to tend downward rather than upward.

Not only do the expenditure schedules in Tables 5.2 through 5.5 represent the recommendations of this study – they also approximate reasonably the projections of those systems of higher education which have developed plans. Although the schedules appear to disagree with the plans of the State College System[5] which call for installation of a second Class D or E Regional Computer Center late in the 1971-73 biennium, the real difference is in the allocation of funds rather than in accomplishing the objectives of this center on schedule. Installation of a much smaller Class F or G satellite computer in 1972-73 will permit St. Cloud State College to develop the staff and faculty expertise to effectively utilize a large computing center; it will provide adequate services to surrounding school districts which, as observed during the course of this study, are anxious to obtain access to services of this kind; and higher education will not be encumbered with the costly excess of computer capacity accompanying a large center installed prematurely. By the time a decision is needed to go ahead with the expansion scheduled for St. Cloud in 1974-75, it will be possible for the State College Board to make a more informed decision on how to proceed, based on experience with the large center in Mankato and the smaller satellite center in St. Cloud.

A SECOND FIVE-YEAR PLAN

Changes in technology and its influence on higher education tend to make a prediction for ten years ahead somewhat difficult with any degree of confidence. If the plan of the first five years

Table 5.1. Existing Computing Facilities in Public Higher Education by Function, 1970-71 (Including Those Approved for Acquisition)

Facility	Purchase Price(c)	Equivalent Annual Lease (0.27 of Purchase Price)	Recommended Support Budget(a) for Instruction and Administration	Actual Budget Support for Instruction and Administration
SYSTEMS AVAILABLE FOR STATEWIDE USE:				
6600 System(b)	$2,560,000(c)	$ 693,900	$ 388,500(c)	$ 227,000
Mankato Regional Center(e)(m)	1,200,000	200,000(m)	285,000(m)	200,000
UNIVERSITY				
West Bank 3200(e)	450,000	121,500	135,000	37,000
Duluth 3200(e)	440,000	118,800	132,000	98,000
Administrative System 360/50	1,500 000	405,000	900,000	688,000
Hybrid Computer(b)	580,000	156,600	52,000	42,000
Time-Sharing from Commercial Vendors	60,000	(60,000)(e)	(f)	(f)
Health Sciences 3300(b)	825,000	222,750	25,000(b)	25,000
STATE COLLEGES				
Small Computers (Instruction and Administration)	967,000	235,000	392,000	325,000
STATE JUNIOR COLLEGES				
Administrative System 1401	163.000	(44,010)	97.800	53,000
HECC FUNDED PROJECTS	253,700(a)	(40,500)	60,000	
State College Projects				
Junior College Time-Sharing Project				
Campus Management Simulation				
AREA VOCATIONAL-TECHNICAL SCHOOLS				
Alexandria HW200	221,000	59,670	33,150(k)	Not Available or Relevant
Mankato 360/25	233,000	62,910	34,950(k)	
Hibbing HW200	232,000	62,640	34,800(k)	
Moorhead	40,000	10,800	2,400(k)	
Willmar	40,000	10,800	2,400(k)	
TOTALS	$9,764,700	$2,360,370	$2,575,000	$1,695,000

(a) The recommended annual support budget is based on 30% of the market value of computer hardware, times the percent instructional and administrative use of the system (assumed 100% unless otherwise mentioned), times a factor of 2 for administrative computers; 1.5 for systems supporting both instruction and administration; 1 for instructional computers and associated hardware; 0.5 for medium-speed remote terminals; and 0.1 for low-speed (teletype) terminals.

(b) These systems are used both for instruction and for research. In Table 5.4, the operating budgets are for instructional usage only. For 1970-71, the instruction versus research usage will be approximately as follows: (a) 6600, 35% and 65%; (b) 3300, 10% and 90%; (c) Hybrid, 30% and 70%.

(c) The market value of the computer equipment listed here is approximately equal to the purchase price, except for the University's 6600, which has a market value of about $3.7 million. It is on market value that recommended support budgets are based.

(e) For planning purposes, these systems are assumed to be 100% instructional.

(f) Included in equivalent annual lease.

(g) For both hardware and support.

(h) Because a large amount of applications programming is required by funded research users, the Health Sciences computer must be supported at the 2:1 ratio characteristic of administrative processing.

(k) For reasons discussed in Table 4.5, support for vocational school facilities has been figured at 50% of equivalent annual lease plus maintenance for computers, and 20% of this for terminals.

(m) Installed at mid-year, so costs are for six-month period.

() Not included in the total, because these expenditures are superseded in Tables 5.3 or 5.5. All other costs in this column remain to be added to Table 5.3 in arriving at total annual facility support.

Table 5.2. Proposed Funding Schedule for Computing Equipment 1971-75 (Purchase Basis, 1970 Dollars)

Facility	1971-72	1972-73	1973-74	1974-75
SYSTEMS AVAILABLE FOR STATEWIDE USE:				
6600 System				
Peripheral Equipment for Remote Terminals	230,000			
Time-Sharing System	240,000	240,000	240,000	240,000
CAI Center	275,000		300,000	
Mankato Regional Center				
St. Cloud Regional Computer		320,000		1,200,000
Duluth Regional Computer	55,000 (Core Expansion)		55,000 (Core Expansion)	
UNIVERSITY				
Administrative Computer System		70,000 (Disc Expansion)		
3200 Core Expansion (West Bank)		55,000		55,000
Special Lab Computers	300,000	300,000	300,000	350,000
Supplement to Health Sciences and Hybrid Instructional Facilities			150,000	
Terminals to 6600	175,000	175,000	175,000	200,000
Terminals to Time-Sharing System	72,000	72,000	72,000	72,000
STATE COLLEGES				
Terminals to Regional Centers	150,000	30,000	150,000	150,000
STATE JUNIOR COLLEGES				
Terminals to Time-Shared Computer System	46,800	33,200	34,000	33,600
Administrative Computer		270,000		
AREA VOCATIONAL-TECHNICAL SCHOOLS				
Terminals	370,000	370,000	408,000	425,000
TOTALS	1,913,800	1,865,200	1,884,000	2,725,600
STATEWIDE LIBRARY SYSTEM			1,470,000	

Table 5.3. Proposed Funding Schedule for Computing Equipment to be Added During 1971-75 (Lease Basis; Annual Lease = 27% of Purchase Price, in 1970 Dollars)

Facility	1971-72	1972-73	1973-74	1974-75
SYSTEMS AVAILABLE FOR STATEWIDE USE:				
6600 System				
Peripheral Equipment for Remote Terminals	62,100	62,100	62,100	62,100
Time-Sharing System	65,000	130,000	195,000	260,000
CAI Center	74,250	74,250	155,250	155,250
Mankato Regional Center				
St. Cloud Regional Computer	–	96,000	96,000	324,000
Duluth Regional Computer	14,850	14,850	29,700	29,700
UNIVERSITY				
Administrative Computer System	–	19,000	19,000	19,000
3200 Core Expansion (West Bank)	–	14,850	14,850	29,700
Special Lab Computers	81,000	162,000	243,000	347,500
Supplement to Health Sciences and Hybrid Instructional Facilities	–	–	40,500	40,500
Terminals to 6600	48,000	96,000	144,000	198,000
Terminals to Time-Sharing System	36,000	72,000	108,000	144,000
STATE COLLEGES				
Terminals to Regional Centers	40,500	48,600	89,100	129,600
STATE JUNIOR COLLEGES				
Terminals to Time-Sharing System	(26) 23,400	40,000	57,000	(82) 73,800
Administrative Computer	44,000	73,000	73,000	73,000
AREA VOCATIONAL-TECHNICAL SCHOOLS				
Terminals	100,000	200,000	310,000	425,000
TOTALS	589,100	1,102,650	1,636,500	2,311,150
STATEWIDE LIBRARY SYSTEM			396,000	396,000

Table 5.4. Approximate Annual Incremental Operating Budget Needs (1970 Dollars)

Facility	Funding Level for 1970-71	Annual Budgets (Increments)			
		1971-72	1972-73	1973-74	1974-75
SYSTEMS AVAILABLE FOR STATEWIDE USE					
6600 System					
Peripheral Equipment for Remote Terminals		34,000	0	0	0
Time-Sharing System	(c)	43,300	43,300	43,300	43,300
CAI Center		40,000	40,000	45,000	45,000
Mankato Regional Center[a]	200,000	160,000	0	0	0
St. Cloud Regional Computer[a]	–	–	53,000	53,000	127,000
Duluth Regional Computer	98,000	16,000	16,000	17,000	18,000
UNIVERSITY					
Administrative Computer	688,000	62,000	60,000	60,000	50,000
Instructional Usage of Existing Instruction and Research Facilities	331,000	220,000	70,000	70,000	71,000
Facilities Expansion					
Remote Terminals to 6600		26,200	26,200	26,200	30,000
Time-Shared Terminals		4,000	4,000	4,000	4,000
3200 Expansion (West Bank)			16,500		33,000
Health Science and Hybrid		–	–	22,500	22,500
STATE COLLEGES					
Small Computers	325,000	0	-25,000	-25,000	-43,000
Remote Terminals		22,500	4,500	22,500	22,500
STATE JUNIOR COLLEGES					
Time-Shared Terminals	(c)	2,600	1,800	1,900	1,900
Administrative Computer	53,000	12,000	15,000	25,000	40,000
AREA VOCATIONAL-TECHNICAL SCHOOLS		20,000	20,000	21,000	21,500
Communications Leasing and Line Costs	19,000[b][c]	81,000	100,000	100,000	72,000
HECC Funded Projects	150,000	25,000	–	25,000	–
Private College Usage Fund		35,000	35,000	35,000	35,000
Total Incremental Operating Budgets	$1,864,000	$803,600	$ 480,300	$546,400	$540,700
STATEWIDE LIBRARY SYSTEM		931,400	1,258,100	489,000	693,400

[a] See footnote a, Table 5.1, for basis on which operating budgets were developed.

[b] Includes high-speed data links at University plus time-shared terminal communications cost at the University.

[c] These costs for the Junior College time-shared network are included as part of HECC-funded projects. They amount to about $15,000 (service), $12,000 (terminals) and $12,000 (communications) for the year.

Table 5.5. Approximate Annual Total Operating Budget Needs (1970 Dollars)

Facility	Funding Level for 1970-71		Annual Budgets (Total Costs)		
		1971-72	1972-73	1973-74	1974-75
SYSTEMS AVAILABLE FOR STATEWIDE USE:					
6600 System					
Peripheral Equipment for Remote Terminals		34,000	34,000	34,000	34,000
Time-Sharing System	(c)	43,300	86,600	129,900	173,200
CAI Center		40,000	80,000	125,000	170,000
Mankato Regional Center	200,000	360,000	360,000	360,000	360,000
St. Cloud Regional Computer		–	53,000	106,000	233,000
Duluth Regional Computer	98,000	114,000	130,000	147,000	165,000
UNIVERSITY					
Administrative Computer	688,000	750,000	810,000	870,000	920,000
Instructional Usage of Existing Instruction and Research Facilities	331,000	551,000	621,000	691,000	762,000
Facilities Expansion					
Remote Terminals to 6600		26,200	52,400	78,600	108,600
Time-Shared Terminals		4,000	8,000	12,000	16,000
3200 Expansion		16,500	33,000	66,000	99,000
Health Science and Hybrid		–	–	22,500	45,000
STATE COLLEGES					
Small Computers	325,000	325,000	300,000	275,000	232,000
Remote Terminals		22,500	27,000	49,500	72,000
STATE JUNIOR COLLEGES					
Time-Shared Terminals	(c)	2,600	4,400	6,300	8,200
Administrative Computer	53,000	65,000	80,000	105,000	145,000
AREA VOCATIONAL-TECHNICAL SCHOOLS		20,000	40,000	61,000	82,500
Communications Leasing and Line Costs	19,000[b][c]	100,000	200,000	300,000	372,000
HECC Funded Projects	150,000	175,000	175,000	200,000	200,000
Private College Usage Fund	–	35,000	70,000	105,000	140,000
Total Operating Budgets	**$1,864,000**	**$2,684,100**	**$3,164,400**	**$3,753,800**	**$4,337,500**
STATEWIDE LIBRARY SYSTEM		931,400	2,189,500	2,678,000	3,371,400

[a] See footnote a, Table 5.1, for basis on which operating budgets were developed.

[b] Includes high-speed data links at University plus time-shared terminal communications cost at the University.

[c] These costs for the Junior College time-shared network are included as part of HECC-funded projects. They amount to about $15,000 (service), $12,000 (terminals) and $12,000 (communications) for the year.

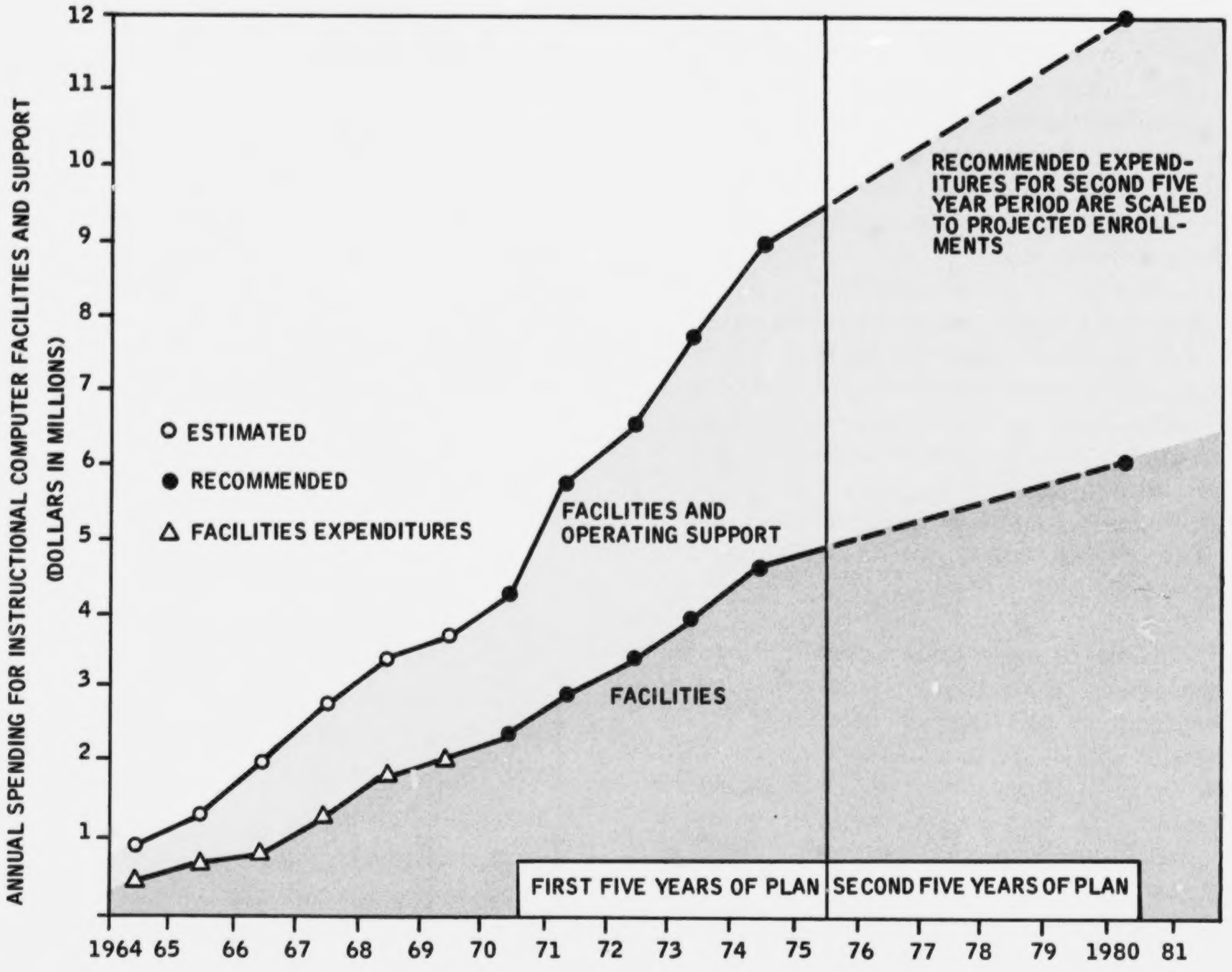

Figure 5.2. Public Funding for Computers in Minnesota Higher Education

succeeds in giving all post-secondary students in Minnesota access to computer facilities in the same degree that, say, Dartmouth College students had in 1967-68, then much will have been achieved. Changes in technology by 1976 may, however, require that a larger segment of the student population have substantial rather than casual or limited exposure to the computer. Such a shift would tend to require more equipment in 1976-81 than is indicated in Figure 5.1, since most of the increases shown there merely reflect increase of student population and replacement or augmentation of aging computers. Before detailed planning for the second five years begins, the regional center approach must be thoroughly evaluated.

A major factor in the second five years would be the decision to expand the regional computer centers in the state colleges to all six colleges. This will depend on the mission and success of these centers and a growth of demand in outstate areas which is difficult to predict at this time. Thus, Figure 5.1 does not prejudice the outcome of the review called for in 1975 by the recommendations.

It is possible to make some general predictions with a certain degree of confidence. The growth of instructional and research computing at the University will almost certainly overload the CDC 6600 by 1976 (Appendix H.4). Thus, it will be necessary to supplement the system by a foreground computer (for example a 6400 to upgrade to a 6700 configuration). This augmentation will probably provide only temporary relief, and a replacement system is indicated in Figure 5.1 in 1979. At that time it may be technically possible to subsume the time-sharing system into the larger facility, but it is difficult now to see what time-sharing will become when it matures. The Area Vocational-Technical Schools are experimenting with terminals. If these experiments are successful and if more data processing programs are started in the Twin Cities area, then by 1976 there will probably be enough utilization to justify a central vocational school facility in the Twin Cities.

During the short history of computer development and application, it has consistently been the case that predictions of growth over one or two years have been too optimistic, yet predictions over five to ten years have been much too pessimistic. It is not unlikely that the forecasts of demand for instructional computing given in this report will follow this tradition

THE PLANS IN PERSPECTIVE

The *Pierce Report*[1] called for a nationwide expenditure by 1972 of $414 million per year for instructional computing alone in order to bring all college computer facilities and programs up to the quality of those colleges which were well-equipped in 1967. Minnesota's proportionate share would be about one-fiftieth of this amount, $8.3 million. Adding together the annual facilities costs in Tables 5.1 and 5.3, and their corresponding support costs estimated in Table 5.5, gives the following approximate annual costs of the proposed Minnesota plan:

ANNUAL COST DATA

Academic Year	Facilities	Support	Total
1970-71	2,360,000	1,864,000	4,224,000
1971-72	2,949,000	2,864,000	5,813,000
1972-73	3,463,000	3,164,000	6,627,000
1973-74	3,997,000	3,754,000	7,751,000
1974-75	4,672,000	4,338,000	9,010,000

When it is recognized that the costs of this plan include administrative data processing, a significant research and public service capacity at the University, and substantial excess capacity for these and other applications at the state colleges, then the cost of the proposed plan is no greater, and perhaps less, than the President's Science Advisory Committee suggested through the *Pierce Report* in 1967.

The proposed expenditures for 1970-75 are shown graphically in Figure 5.2, bracketed by estimated expenditures during the previous six years and projected costs for 1975-80. The two features of these graphs which are most conspicuous are the leveling off in expenditures for computing in higher education during the 1968-70 period, and the increased rate of funding recommended for 1971-75, which compensates for the reduced growth rate during the previous few years. After 1975, the growth rate projected is strictly proportional to enrollment and does not allow for any inflation of the 1970 dollar.

Although the total cost per year of these recommendations in 1975 is certainly formidable, it does not appear quite so staggering on a per-student basis. Assuming about 160,000 students in public institutions in 1974-75, the cost of computing averages to about $56 per student per year. This compares with $60 per student per year estimated for achieving similar levels of instructional computing in the *Pierce Report*[1]. The same report related this to two other functional costs of higher education. College and university libraries, an instructional resource which is generally available to students and faculty in the same way the Pierce Committee wanted computers to be available, cost between $50 and $200 per student per year in 1966. And chemistry laboratory instruction costs about $95 per year per chemistry student. On this basis, the costs proposed in this report appear reasonable.

Cost per student per year in the four public systems of higher education in Minnesota are estimated in Table 5.6. These have been derived from Table 4.5 rather than the tables in this section because that table more readily reflects the cost for general instructional computing and administrative processing in each of the systems, and does not include the excess capacity for research and public service. Hence, the cost-per-student figures in Table 5.6 are estimates of actual student-related expenditures. The relatively high cost of computing at the University is an accurate reflection of the high cost of graduate and post-graduate professional training in general, the bulk of which is concentrated at the University. The lower cost of computing in the state colleges is partially a result of the fact that, since they have no separate administrative computer, it has been assumed that their administrative work is accommodated on the third shift of the instructional capacity they use. No extra cost has been incurred in Table 4.5 for state college administrative processing (except for mass storage) in contrast to the other two collegiate systems. In practice, this assumption is somewhat unrealistic; there will be some additional staff and operating support costs and these are reflected in Tables 5.1, 5.4, and 5.5.

The overall cost-per-student in the vocational-technical schools is not much different from the other institutions. But when it is recalled that most of the computing there is done by data processing students and most of the rest by students in accounting, the story changes. However, even these high costs are not unreasonable when placed in perspective. The vocational schools are the only post-secondary institutions with adequate program cost data. Computer facilities account for about one-half of the cost of training students in data processing, with faculty accounting for most of the other half – a 1:1 hardware-to-staff ratio (recall that staff was not included for vocational schools in Table 4.5). This gives an approximate program cost of $1,300 per student per year. Two entirely independent estimates of this cost during visits to two Area Vocational-Technical Schools resulted in figures of about $1,200 per student per year. This is about the same as the cost of training a machinist, and somewhat less expensive than training a welder. The situation would be rather similar for computer science and certain engineering students at the University. If Minnesota wishes to provide this kind of education, the costs must be borne. Such estimates also point up the desirability of program budgeting, so that decisions about programs can be made on a more informed basis.

Table 5.6. *Annual Cost Per Student of the Computing Capacity Proposed for Minnesota Higher Education in 1975, in 1970 Dollars (Derived from Table 4.5)*

System	Approximate Total Monthly Cost of Computing in 1975	Approximate Total Annual Cost of Computing in 1975	Approximate Total Enrollment in 1975	Approximate Annual Cost of Computing Student in 1975
University	$340,000	$4,100,000	61,000	$ 67
State Colleges	172,000	2,100,000	54,000	39
Junior Colleges	69,000	828,000	27,000	31
Area Vocational-Technical Schools	65,000	780,000	19,000	41
Data Processing		600,000	900	667
Accounting		180,000	1,200	150
TOTALS	$646,000	$7,808,000	161,000	$ 48

Finally, the total operating costs of public higher education in Minnesota in 1974-75 are estimated at about $370 million[11]. The cost of achieving the level of computing proposed here will amount to about 2.5% of this total operating cost. Again, this compares conservatively with the estimate by the Pierce Report in 1967, that achieving their goals for general instructional computing would consume about 4% of the annual cost of higher education.

If the State of Minnesota desires to achieve the goals set forth here for computing in higher education, funding must come from state sources for the near future at least. The Federal budget situation and the current recession affecting the computer industry do not auger well for Federal grants or substantial manufacturers' discounts. Despite the pessimistic outlook, higher education must do everything it can to tap these outside resources, which implies in turn that enough flexibility must be built into funding and coordinating mechanisms to provide matching funds when they are needed. The outlook for outside funding cannot get much worse; it could improve considerably during the next several years. But in either case, we believe that tangible evidence of a commitment by Minnesota higher education and the Legislature to coordinated planning guidelines, such as represented by this report, will significantly improve the changes of obtaining outside resources to implement the plans.

PRIORITIES

Despite the evidence that the proposed plan is not an unreasonable expense for higher education, its total cost by 1975 is clearly high enough to cause concern by the Minnesota taxpayer and his elected representatives. It may not be possible to achieve the desired level of computing capacity by 1975 — aiming at that level for 1980 would, in fact, distribute the rate of increase of spending more uniformly (see Figure 5.2). If support cannot be provided at the level suggested, then it is recommended that priorities for spending available funds should be as follows:

1. Support for existing facilities, especially the statewide or regional facilities at the University of Minnesota and Mankato State College.
2. Establishment of a limited-capacity statewide time-shared computer facility to provide service at slightly above present levels to the junior colleges, the University, and the private colleges which wish to use

it. This is the only kind of instructional computer service presently economical for and useful at the junior colleges.

3. Support for establishment of a statewide center to support development work on computer-assisted and computer-managed instruction. The potentials for economies and effectiveness of this development are too great to ignore.

This minimal increment would amount to about $900,000 for 1971-72, as compared with $1.4 million indicated for the recommended plan.

But it is properly the responsibility of higher education itself to set these and other priorities, either within institutions and systems as in the past, or through the Minnesota Higher Education Coordinating Commission as recommended in this report. Priorities for computing cannot be established independently of other demands for services, faculty, equipment and supplies, and buildings, nor independently of the programs which exist in the several institutions and which may require computing or other support for their existence. This report may serve as a useful planning guideline, but it is the people within higher education – faculty, managers of academic computing centers, and administrators – who must ultimately make the decisions, and who are equipped with the knowledge and experience to do the best job possible with the available resources.

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H.4 Academic Computing at the University of Minnesota, 1969-1975, Frank Verbrugge, Director of University Computer Services, July 1970.

H.5 Tables Summarizing Existing (August 1970) Computing Facilities and Programs in Minnesota Higher Education.

H.6 Analysis of Goals and Computer Resources Needed for Minnesota Higher Education.

H.7 Tables Detailing Facilities to Meet the Goals and Cost Analysis.

H.8 A Cost Comparison of Time-Shared and Remote-Job-Entry Computing.

H.9 Deployment Configuration for Higher Education Computer Networks.

H.10 Summary of Enrollment Data and Projections for Minnesota Post-Secondary Education.

PART V
LOCAL GOVERNMENT

TABLE OF CONTENTS

Section / Page

1. INTRODUCTION 5-1
    - MAGNITUDE OF THE TASK 5-1
        - Minnesota Awareness 5-1
        - Legislative Consideration 5-2
        - Governor's Action 5-2
        - Governor's Committee 5-3
        - Administrative Action 5-3
        - State-Local Data Systems Group 5-3
    - STUDY OBJECTIVES AND SCOPE 5-4
        - Plan for Local Governments 5-4
        - Study Methods 5-4
2. STATE OF THE ART IN LOCAL GOVERNMENT 5-5
    - THE LOCAL GOVERNMENT PROBLEM 5-5
    - CONCEPTUAL FRAMEWORK 5-5
    - GENERAL STATUS OF LOCAL GOVERNMENT INFORMATION SYSTEMS 5-7
        - The Dynamics of Information Flow 5-7
        - Background Material 5-7
        - USAC Project 5-8
        - State Action 5-8
    - MINNESOTA LOCAL GOVERNMENT INFORMATION SYSTEMS 5-10
        - Minnesota County and Municipal Government 5-10
        - MINCIS 5-10
        - Minnesota School Districts 5-15
3. APPROACH TO LOCAL GOVERNMENT INFORMATION SYSTEMS AND COMPUTERIZATION 5-23
    - POTENTIAL PITFALLS 5-23
    - BASIS FOR ALTERNATIVES 5-24
    - COST/BENEFIT 5-25
4. RECOMMENDATIONS 5-27
    - GENERAL RECOMMENDATION 5-28
    - ORGANIZATIONAL REQUIREMENTS 5-28
        - Intergovernmental Commission on Information Systems 5-28
        - Local Government Division 5-30
        - Area Computer Center Board 5-31
        - Systems Coordinators 5-31
    - APPROACHES TO COOPERATIVE CENTERS 5-31
        - Alternate Methods 5-31
        - Location: Regional Base Preferable 5-32
        - General Criteria for Centers 5-32
        - Area Computer Centers 5-33
    - ORIENTATION AND TRAINING 5-34
    - FUNDING 5-35
    - IMPLEMENTATION SUGGESTIONS 5-36
    - INTERIM ACTION 5-38
    - REFERENCES 5-39

LIST OF FIGURES

Figure		Page
2.1	The Geographical Distribution of State Law Enforcement Agencies Served by MINCIS (Minnesota Crime Information System)	5-16

LIST OF TABLES

Table		Page
2.1	Tabulation of County Applications	5-11
2.2	Tabulation of Municipal Applications	5-12
2.3	EDP Operations Environment for Minnesota Counties and Municipalities	5-13
2.4	EDP Training for Minnesota County and Municipal Personnel	5-14
2.5	TIES (Total Information for Education Systems)	5-19

1. INTRODUCTION

The general introduction, Part I of this report, includes a discussion of the pressures upon government at all levels and of the relevance of information systems to public administration. Nowhere are the pressures stronger than in local government. In the vernacular, the local governments are "where the action is". The "action" is not only in terms of those matters occupying the front pages of the daily newspapers although they are important but also in the many routine services rendered directly to citizens.

It is at this level that most of the day-to-day citizen/public servant relationships occur. It is largely here that the public is served in a direct sense. It is also here that the science and art of systems analysis and computerization can most dramatically assist public administrators in effecting both better service and economies.

In this introductory section, an effort is made to put the local government problem in perspective by looking at amounts and rates of expenditures. Evidence of awareness of Minnesota's problem is then reviewed, and the methodology of the project discussed.

Section 2 outlines concepts of local government information systems and summarizes the status of their development nationwide and in Minnesota. Section 3 contains a discussion of pitfalls in approaching the problem and reviews the principal decisions relevant to moving into information systems. Limited comments on cost benefit are included. Section 4 is devoted to discussion of a plan for Minnesota local government information systems and recommendations to implement the plan.

MAGNITUDE OF THE TASK

Because of the lack of solid bench marks in local government information systems, there is no way to produce a measure of the real magnitude of the task in Minnesota. The gross measures in Table 1.1 in Part I of this report give some data that are indicative of state-local relativities and growth rates. At present, state governments are generally more deeply involved in information systems implementation than are local governments. As the latter move more aggressively in this field, as they inevitably must, expenditures will rise materially. It may well be that expenditures for information systems and other computerization in local governments will exceed those by state governments in the near future.

The important question is how best to meet the needs — by individual development or by some sort of coordinated approach. It is virtually certain that uncoordinated efforts to develop and implement information systems and other computerization by individual local governments will lead to astronomical overall costs in one group of communities, and in another group, abandonment of the effort because of costs. The extent of the Minnesota problem is 87 counties, 139 municipalities (population of 2,500 or greater), 440 school districts covering both elementary and secondary education, and a substantial number of regionally based organizations.

Minnesota Awareness

There has been considerable concern in Minnesota over the problem of local government computerization. At the state level, this concern has been expressed by the State Legislature, the Governor, the Governor's Committee on State Information Systems, the State Commissioner of Administration, the Commissioner of Education, and others.

Legislative Consideration

The Legislature considered legislation at its 1969 session which called for the appointment by the Governor of an Intergovernmental Board on Computerization. This Board was to advise a proposed Commissioner of Information Systems on "Goals and objectives for intergovernmental and intragovernmental information systems" and "Priorities and policies governing coordination, cooperation, joint efforts, working relationships, and cost sharing relating to the development, implementation, and operation of intergovernmental and intragovernmental information systems and other computer services". A staff to assist the Board was to be furnished by a Commissioner of Information Systems. After referral to a conference committee, the legislation was voted out too late to pass; but it is understood that this section had general acceptance. It is clear from the language of the bill that the Legislature is well aware of the intergovernmental information needs, as well as the information systems and other computer needs, within local government.

Governor's Action

In Executive Order No. 15, issued in May 1968, the Governor assigned to the then new Computer Services Division the following responsibility:

> Take action to develop information systems to make more effective the use of state funds by political subdivisions including providing the systems design and programming capability necessary to develop generalized computer programs for local units of government and, when feasible, the computer capacity to handle those programs.

Lack of resources, both in funds and personnel, prevented an aggressive state effort in other than the MINCIS program. The Computer Services Division, however, was instrumental in the next year in efforts to establish local government coordinating mechanisms, a successful effort which is described later. Further, it provided whatever support and advice it could to any cooperative efforts underway or in the planning stage.

The Governor, in his January 1970 Executive Order No. 56, expanded upon the 1968 directive. The paragraphs pertinent to local government read as follows:

> A major area of information systems in which the state has both a financial and operational interest is in the political subdivisions of the state. Local governments in general have neither the funds nor the personnel necessary to the development and implementation of such systems. The need, however, is pronounced. To assist local governments in this area of great concern, the Division will take action to develop local government information systems including providing the systems design and programming capability necessary and, when feasible, the computer capacity to handle those programs on a pilot project basis. In accomplishing this, the Division will coordinate its efforts with other interested agencies to assure integration of resources and elimination of redundant efforts.
>
> To attain its objectives in the most effective manner at both the state and local government levels, the Division will utilize to the extent practicable systems design and programs available from other states, from governmental jurisdictions, and from private sources, reciprocating to whatever extent is appropriate and legal. It will initiate cooperative systems and/or programming efforts with other states when practicable.
>
> Information systems and other computer services are vital to the efficient and effective management of all agencies of local government. The importance of development of such systems increases daily because of the growing demands on local government for

> services on one hand and the increasingly serious local government revenue problem on the other hand. To assist in attacking this problem and in addition to the action specified in the two preceding paragraphs, the Division is to submit a report to the Governor no later than September 1, 1970, outlining the needs of local government for information services and plans and programs to meet those needs in the most expeditious and efficient manner.

(This report is intended to serve as the base for the Computer Services Division report called for in the preceding paragraph.)

Governor's Committee

The Governor's Committee on State Information Systems has had a continuing interest in the problem. The committee chairman has identified it as the area of information systems most in need of assistance and holding the promise of greatest payoff. Committee members have become well acquainted with the general situation in local government. In early 1970 the Committee recommended a reorganization of the Computer Services Division to include an organizational unit with responsibility for assisting local government.

Administrative Action

The Commissioner of Administration implemented the reorganization recommendation in April and authorized expenditure of special appropriation funds to finance the functions of the Local Government Unit. Funding is small, but a beginning has been made.

Commissioners of the Minnesota Department of Education, both the present commissioner and his predecessor, have been deeply interested in the development of information systems and computerization in the public education system of the State. Legislation authorized by the Board of Education for introduction at the 1969 Session on the subject was deferred in favor of the provisions in the legislation cited earlier. The desire of the Board of Education is to prevent unnecessary proliferation and redundant development cost. Section 2 contains a more detailed discussion of State action related to school district information systems and computerization.

State-Local Data Systems Group

This topic has, of course, been an extremely important consideration in many local governments. Some jurisdictions have moved ahead alone with varying results. Sometimes there have been cooperative efforts. Many times nothing has happened. The actual results in Minnesota are discussed in some detail in Section 2.

Through the efforts of several agencies, a group of persons interested in the local government problem began holding informal meetings in 1969. The moving forces included the League of Minnesota Municipalities, the State Computer Services Division, the Upper Midwest Research and Development Council, the Minnesota Higher Education Coordinating Commission, the Center for Urban and Regional Affairs of the University of Minnesota, and the Metropolitan Council. Agreement was ultimately reached on the formation of an organization to be called the State-Local Data Systems Group. Membership invitations were sent in July to representatives of appropriate agencies; as of this writing the first meeting had not been held. The purpose of the group is:

> To assist in the development of coordinated information systems which will enable State and local government to individually and collectively obtain maximum benefit from new technology in the data processing field.

It is expected that the group will be in a position to meet with legislative committees at the 1971 Session in discussion of local government computerization.

STUDY OBJECTIVES AND SCOPE

Plan for Local Governments

The objective of this study as related to local government is to develop a generalized plan for the organization, implementation, utilization, and operation of computer systems. This is a much more general objective than those in the other two sections of the report, necessarily so because of the status of local government systems and computer efforts. Accordingly, the report outlines such a generalized plan.

Study Methods

To obtain an understanding of the present situation and plans related to local government information systems, a set of four questionnaires was designed. The first two questionnaires, one for municipalities of 2,500 or greater and one for the counties, asked about present and planned data processing applications. Following analysis of the first questionnaires, a second set of more detailed questionnaires were sent to a limited number of counties and municipalities. Again, the two questionnaires were highly similar, going into great detail on data processing applications and plans. Staffs of the Association of Minnesota Counties and the League of Minnesota Municipalities were most helpful in assisting with the distribution of the questionnaires. The high level of response was directly attributable to that assistance.

Information relative to school districts was obtained by discussions with officials of the Minneapolis School District; TIES, an organization of school districts established under the Minnesota Joint Powers Act; and the State Department of Education. Discussions were also held with personnel of many Minnesota governmental jurisdictions – county, municipal, metropolitan, and state, and with such organizations as the Association of Minnesota Counties and the League of Minnesota Municipalities.

Extensive interviews were held with personnel of the states of Iowa and Oregon to obtain first hand data on local government information systems in other states. Many studies concerning local government information systems plans and progress were reviewed. A nationally known authority on local government information systems, Dr. William Mitchel, provided background information for the study.

2. STATE OF THE ART IN LOCAL GOVERNMENT

In the previous section a general need for systems analysis and computerization in local government was stated and the demonstrated interest and concern on the subject at the state and local level outlined. In this section a more detailed discussion of the concepts of and approach to information systems in local government is first presented. A review is made of some developments in local government information systems at the Federal level and in other states. Then the status of such systems in Minnesota is summarized.

THE LOCAL GOVERNMENT PROBLEM

The business of local government is serving its citizens, a business engaged in with varying degrees of success as any other business. The ultimate mark of success of a governmental unit is the quality and costs of the services which the governmental officials have been authorized by the citizens to undertake. Effective execution of a particular service program requires:

- Clear definition of program objectives.
- Planning the system to reach the objectives.
- Allocation of human, material, and financial resources.
- Execution of the program.
- Continuing control of execution and evaluation of results.

Systems analysis and computerization can be extremely helpful in these efforts. This is, of course, true for any organization. It is particularly true for local government. The governmental programs and their resultant products are mainly services, not goods. The computer itself may be the machine that produces the product — business licenses, birth certificates, building permits, warrants, welfare payments, etc. The computer can serve as a repository of most of the raw data necessary to produce such products. And the computer, drawing upon its raw data and its monitoring of "production", can provide information for management to control program execution and subsequently to evaluate program accomplishment.

Historically, a vast amount of data has been obtained in the course of governmental operations. Often the data have been obtained redundantly, sometimes repeatedly so. Generally, the data are filed or stored in a manner that makes retrieval difficult and research use almost impossible. Only rarely is it possible to relate data from separate files, short of a massive research project. Procedures for handling data, both manual and mechanical, have been based on the need to process paperwork for a particular purpose. The approaches to information systems to date have followed the same pattern, with emphasis on the efficiency of a particular process rather than on the effectiveness of the programs for service.

A continuation of this approach, while it may bring certain operating efficiencies, will contribute little to the solution of the overwhelming problems facing local government today. In a systems sense, the classical error is being perpetuated — improvement is attempted in *how* to do something when emphasis should be on *what are the objectives*. The cart has often been before the horse.

CONCEPTUAL FRAMEWORK

Initially what is needed, as stated repeatedly in the State part of this report, are clear objectives for each program for service. This management responsibility must be accomplished prior to undertaking an information systems effort. Systems analysts may then address the problem of how to reach the objectives in each service program. To the extent that the systems analysis relates to the information systems aspects of the several services, a pioneering effort is not needed. A framework was proposed by Hearle and Mason in 1963[1] and has been generally supported by actual experience and research since then.

Information systems were discussed at some length in Part I of this report. Supplementary thereto is the following definition, slanted toward local government, which may be helpful in clarifying some of the concepts advanced later.

> An information system consists of people, computer equipment and related programs, data unit definitions, and institutional procedures. . .interacting in a prescribed systems pattern. . .in order to capture, collect, store and facilitate on a continuing basis, the automated use of data for operational requirements. . .and for various summarizing or analytical techniques relevant to the definition of community problems, the search for program goals, cybernetic flow for evaluation and control, and for intergovernmental exchange, as such data and their processing are related to both the internal affairs of the agency and the external environment which they serve.[2]

The basic concept of local government information systems is summarized in the following:

- Data are organized into four kinds of files: natural persons, legal persons, real property, and personal property.
- The data elements in the files are capable of serving day-to-day operating needs and planning and research requirements, both intra and intergovernmental.
- The data elements in the individual governmental service files are limited to those unique to the requirements of the agency or agencies using that file, with data common to all files found in a master file.
- The files are interrelatable so that:
  1. **Maximum service can be provided.** For example, a citizen may change his address. One notification of that change to any agency of the local government would accomplish the change in all the files. A more complex example: a citizen may wish to build a new home. Application for the building permit could automatically trigger the computer to set up controls over all of the pending subsequent governmental activities required. The completion of those steps, such as building inspection, could be computer-monitored.
  2. **Analysis can be readily accomplished.** For example, a city planner may wish to study the relationship between quality and location of housing and the welfare caseload. Several files could be queried, providing groupings of data necessary for the analysis.
- Interrelating files requires the adoption of unique identification numbers so that the same records on different files may be related. This means that a unique number is applied to each natural person, each legal person, and each piece of real and personal property in all files relevant to them. In addition, the definition and structure of each element of data are standardized.
- Information systems are computer-based so that updated files can be promptly available and so that appropriate management control over program performance can be accomplished.
- Confidentiality of data is maintained so that only authorized persons may have access to data from any one file. Confidentiality safeguards are established and rigorously enforced.
- Routine decision-making is transferred to the computer in many cases. For instance, a businessman may apply for a license to provide entertainment in his restaurant. Appropriate software for the computer

system can quickly determine from the land parcel entries for buildings whether or not the zoning laws permit such a license to be issued.

The foregoing focused on the needs of one local government. To that must be added the need for standardization of the structure of the data base *among* local governments so that data and programs may be readily exchanged.

It is emphasized that implementation of this basic concept is a large task requiring a sizable commitment of management and money. It can be done, however, in a series of planned steps. It is the premise of this report that it must be done. It is a further premise that it can only be done timely and efficiently on a coordinated and cooperative basis.

GENERAL STATUS OF LOCAL GOVERNMENT INFORMATION SYSTEMS

The Dynamics of Information Flow

In April 1968, Intergovernmental Task Force on Information Systems issued a report entitled "The Dynamics of Information Flow".[3] The task force was set up jointly by the U.S. Bureau of the Budget, Council of State Governments, National Association of Counties, National League of Cities, U.S. Conference of Mayors, International City Managers' Association, and the Advisory Commission on Intergovernmental Relations. Its purposes were to:

- Identify impediments to attaining an effective flow of information within and among governments, and
- Recommend actions that could be taken at the Federal, State, and Local levels.

Reprinted on page 5-21 is an excerpt from the chapter of the report relating to local government. It is a succinct statement of the problem at the local government level, emphasizing the need for coordination.

Background Material

There is currently a substantial body of knowledge relating to and depicting the use of computers by local government. Additional information is being generated at a rapid pace. As yet there is no central clearing house for these applications, nor are there standardized reporting systems which would produce an inventory of local government applications.

In July 1969, the U.S. Department of Housing and Urban Development included as part of the request for proposal for the USAC project discussed later, considerable information on use of computers by cities. It is a fairly comprehensive statement of the state-of-the-art, present use, and the potential for local government information systems. In a more limited sense, there is information on research conducted under Federal grants in the use of computers by local school districts. Information concerning county applications is scanty but is becoming more available in fields of health, highways, property assessment, and welfare. In addition, several higher educational institutions have developed courses devoted to orienting elected and administrative officials in the use of computers and exploring the applicability of computer technology to local government problems.

There is, of course, a vast array of information in the public administration professional periodicals and computer trade journals. Most of this reports on specific applications in individual governmental jurisdictions. An extremely wide range is covered from routine, straightforward "business-type" applications, such as utility billing, to esoteric mathematical models for transportation and land use planning. In fact, a measure of the present and potential redundancy in systems design and development cost in local government might be obtained by means of an exhaustive review of the professional and trade literature.

USAC Project

One current effort dealing directly with municipalities justifies special comment. Seven Federal agencies have jointly financed a $12,000,000 project under a consortium designated as the Urban Systems Advisory Committee (USAC). Administrative responsibility for the project rests with the Department of Housing and Urban Development. The objective of the project is to develop prototypes of major computer-based information systems for municipalities. Governmental programs were grouped in four systems: public safety, human resources, physical and environmental planning, and financial and administration. Two cities were selected to develop all four systems. Each of four other cities were selected to develop one of the systems. (St. Paul, Minnesota, is one of the latter four and is developing the human resources system.) The several projects are attempting, through carefully defined research, to develop systems and programs and the related documentation which can be transferred to other cities. The objectives stated are:

1. To improve the information and decision-making capabilities of municipalities.
2. To provide a broader approach in the research and development of municipal information systems, specifically the following:
    - Standardization of data and inventories of data, both vertically through successive levels of government, and horizontally at each level.
    - Economic solutions to the problems of data acquisition, data management, and data use.
    - Solutions to the problems generated by sensitivity of information (protection of confidentiality).
    - Solutions to the problems of subsystem and system linking, both vertically and horizontally (facilitating systems compatibility and/or interfacing).
3. To learn more of the impacts of the implementation of municipal information systems (implications for administrative organization and behavior).
4. To provide for expansion and interfaces with other public or private systems, and for interfaces with existing municipality-related planning agencies (in urban transportation and comprehensive area planning).

At the end of the project in 1973, it is expected that at least some part of an information system will be operating in each of the six cities. If the project objectives are fully realized, prototypes for municipal information systems should become a reality and a nationwide pattern set. St. Paul's participation presents an opportunity of great potential value to Minnesota.

State Action

California

Representative of action in several states is that taken by California, a state which appears to be in the forefront of interest and activity in developing local government information systems. Initially, there was a cooperative, spontaneous effort in California by an informal committee of state and local personnel to discuss the problems. This interest led to the Governor's appointing a special advisory board formed from representatives of cities, counties, school districts, and state agencies and charging the board with development of a program for the use of computers and the development of policies and standards which could be used by the state and local governments in pursuing computer applications.

Hearings and investigations conducted by the Board generated legislative interest which resulted in 1967 legislation establishing a semiautonomous Intergovernmental Board on Electronic Data Processing. The twelve-member board appointed by the Governor includes four from state agencies, three representing county governments, three representing city governments, and two representing school districts. (The Board and its objectives are used as a partial basis for a similar agency recommended for Minnesota in Section 4.)

Pennsylvania

In Pennsylvania, an agency somewhat similar to the California Board was established recently. It is named the Pennsylvania Interagency Municipal Information Systems Advisory Committee and has the following responsibilities:

- Coordinating the roles and actions of the member agencies as they affect municipal information systems.
- Encouraging intergovernmental (Federal-State-Local) cooperation and coordination in the development of information systems.
- Encouraging interlocal cooperation to insure maximum use of new systems developments and to simulate efficient use of manpower, equipment, and programs on a cooperative basis.
- Serving as a single point of contact within the Commonwealth concerning the relationship of municipal information systems to Commonwealth agencies and information systems.
- Monitoring municipal systems developments within the Commonwealth and providing a collection point and a clearing house for information about municipal systems development statewide and nationwide.
- Encouraging the use and the further development of standardized data elements and related codes.
- Encouraging and recommending staff and fiscal support for the research and development of integrated municipal information systems.

There are a myriad of computer applications in local government around the country. These run from simple processing operations to highly sophisticated, complex on-line systems. Some use is being made of computers for simulation. There are, however, few if any full scale information systems in operation. Of particular interest are examples of cooperative efforts, for it is through such efforts that the resources and capacities necessary for information systems will generally emerge.

- A well known and carefully planned cooperative venture is the San Gabriel Valley project in which a series of cities, under a joint powers arrangement, agreed to develop a common computer center and commonly shared programs. A private foundation assumed a major role in funding this particular development. The results to date do not provide an adequate basis upon which to generalize how cooperative ventures should be established.
- In Alachua County, Florida, several departments which were duplicating information gathering and record keeping activities have consolidated efforts and are sharing a computer. Those using the computer include the sheriff's office, board of county commissioners, supervisors of elections, jury commission, health department, board of public instruction, tax assessor and tax collector, general hospital, and a junior college.
- A cooperative venture similar to TIES in Minnesota, discussed later, is OTIS (Oregon Total Information Systems) in Eugene, Oregon, serving a number of school districts with substantial student enrollment. OTIS, like TIES, is an outstanding demonstration of what cooperation can provide.

The project investigations in this area also revealed instances in which there had been developed successful coordinated county-city development of independent facilities with a substantial interchange of data between the jurisdictions. One such operation is in Oregon where Lane County, the City of Eugene, and several other cities have entered into a cooperative effort in the use of computer facilities. The computer is located on county property in Eugene, but there are remote terminals to the various cities. This arrangement is reportedly working out quite well. Both cities and Lane County have more computer power than either could afford alone.

MINNESOTA LOCAL GOVERNMENT INFORMATION SYSTEMS

It is, of course, impossible to detail in this report all of the systems analysis and computerization activity in Minnesota local governments. An attempt has been made, however, to present an overview of first, the situation in county and municipal government and next, status of the school districts.

Minnesota County and Municipal Government

It was indicated in Section 1 that two sets of questionnaires were used to obtain an overview of data processing in Minnesota counties and municipalities. The first set included one page questionnaires, one for counties and one for municipalities, and obtained data on present and planned applications. These questionnaires are summarized in Tables 2.1 and 2.2. Seventy-eight of the 87 counties (90 percent) returned the questionnaire as did 111 of the 139 municipalities over 2,500 in population (80 percent). Only those governments indicating present or planned applications are included in the tables. The applications most heavily mechanized are utility billing, payroll accounting, general accounting, and assessment processing.

A second and much more detailed questionnaire was sent to eleven counties and forty municipalities. Five of the counties and twenty of the municipalities responded. Financial data obtained via the second questionnaire indicated that only five of the 25 respondents are spending as much as one percent of their budget on "data processing." Ten of the responding agencies claim an existing long-range plan for computerization or report that such a plan is currently being developed. Most of these ten jurisdictions are planning some type of cooperation with other units of government in systems design and programming, computer facilities, and/or data sharing.

An effort was made to obtain a measure of the present and planned activity in various areas of computer management and operation. The data, summarized in Table 2.3, give an indication of the considerable room for development, even in the group of local government jurisdictions considered the most advanced.

Table 2.4 shows county and municipality data on education and training in computerization. The general level of training in the twenty reporting jurisdictions is a matter for great concern. Until the personnel responsible for planning and implementing systems and computerization efforts obtain adequate education and training, significant progress toward information systems is simply not possible.

The picture presented by the five county responses is, in some ways, more encouraging. In the area of EDP training, there is more activity; and the level of computer sophistication is higher, as shown by the number of items with which the counties have had experience. Population base is probably a significant factor here; larger local jurisdictions have a more critical need for some method of handling the huge volumes of data required to provide services and to administer a large organization and, therefore, have been more active in using computers to fulfill this need.

In summary, the questionnaires show a recognized need in many county and municipal governments, a checkered pattern of development, and either a small beginning or no effort whatsoever in most governments. County and municipal governments are generally at the threshold and at a point where coordination and cooperation can be most easily realized. Accomplishments by certain jurisdictions, for example, Hennepin County, may be helpful in accelerating the overall effort.

MINCIS

A cooperative effort between state and local governments rather than among local governments, is MINCIS (Minnesota Crime Information System), discussed briefly in Part III

Table 2.1. Tabulation of County Application

COUNTY	HOSPITAL NURSING ACCT.	PAYROLL ACCT.	GENERAL ACCT.	DITCH ASSMT ACCT.	PERSONAL PROP. INV.	VOTE COUNTING	VOTER REGISTRATION	STATISTICAL RECORDS	ASSESSORS RECORDS	PROPERTY RECORDS	FINANCIAL STATEMENT	ENGINEERING COST ACCT.	GAME AND FISH ACCT.	OTHER MGMT. INFO.	BUDGET CONTROL	ASSESSMENT DATA	TAX COMPUTATION	TAX STATEMENTS	UTILITY BILLING	WELFARE
ANOKA		■	■			■	▨	▨	■	■	■	■	■	■	■	■	■	■	■	■
BLUE EARTH																	▨	▨		
BROWN		▨	▨	▨					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		
CARLTON		■	■		■		▨	▨	■	■	■	■	▨	▨	■	■	■	■		■
CASS			▨								▨						▨	▨		■
CROW WING		■	■								■			■		▨	▨	▨		
DAKOTA		▨	▨	▨	▨				▨	▨	▨		▨		▨	▨	▨	▨		
FREEBORN		■	■	▨				▨	▨		■				■	▨	■	▨		
GOODHUE	▨	■	▨	■				■	■			▨		■		■	■	■		■
HENNEPIN	■	■	■		■	■		■	■	■		■		■	■	■	■	■		■
ITASCA	■																	■		
KANDIYOHI		▨	▨	▨					▨		▨	■	▨			▨	▨	▨		
MOWER		▨	▨	▨				▨	▨	▨	▨		▨	▨	▨	▨	▨	▨		
OLMSTED	■	■	■		■	■	■	■	■	■	■		▨	■	■	■	■	■		■
POLK		■	■								■		■			■	■	■		
RAMSEY	■	■	■			■		■	■	■	■	■			▨	■	■	■		■
RICE	■	■							▨						▨	▨	■	■		
SCOTT	■	▨	▨	■	■	■	■	▨	■	▨	■	▨	■	■	■	■	▨	▨		
ST. LOUIS		■	■							■	■	■	▨		■	■	■	■		■
WASHINGTON		▨	▨		▨				▨	▨	▨					▨	▨	▨		
WRIGHT		▨	▨						▨	▨	▨				▨		▨	▨		

■ ACTUAL

▨ PLANNED

Table 2.2. Tabulation of Municipal Applications

MUNICIPALITY	UTILITY BILL.	PAYROLL ACCT.	GENERAL ACCT.	SPEC. ASSMT. ACCT.	INVENTORIES	VOTER REGISTRATION	STATISTICAL RECORDS	ASSESSORS RECORDS	PROPERTY RECORDS	ENGINEERING	ELECTIONS	OTHER MGMT. INFO.	COST. ACCT.	LICENSING	BUDGET PLANNING
ALBERT LEA	■	■	■	▨											
ANOKA	■	■	■		■										
AUSTIN		■	■	■	▨	▨	▨		▨	▨	▨	▨			
BLOOMINGTON	■	■	■	▨	▨	■	▨	▨	▨	■	▨	▨			
BROOKLYN CENTER	▨	▨													
BROOKLYN PARK	■										■				
BURNSVILLE	▨	▨		▨			■	▨	▨						
COLUMBIA HEIGHTS	■		▨	▨				■	■		▨				
COON RAPIDS	■	▨			▨	▨					■				
CRYSTAL	■	■	■	■											■
DULUTH	■	■	▨	■	■	▨		■	■	▨					
EDEN PRAIRIE	▨			▨				▨	▨						
EDINA	■	▨		■		■		▨	▨						
FAIRMONT		▨	▨	▨											
FERGUS FALLS	▨				▨							▨			
FRIDLEY	■										■				
GOLDEN VALLEY	■	■	■	■											
INVER GROVE HEIGHTS	■	■	■	▨											
LE SUEUR	■														
MANKATO	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨		
MINNEAPOLIS	■	■	■	▨	■		■	■	■	■		■			
MOORHEAD	▨			■											
NEW HOPE	▨	▨	▨	■	▨						■				
NORTH MANKATO	▨	▨	▨	▨											
OAKDALE	■							■							
ORTONVILLE	■	■	▨		▨		▨					▨			
OWATONNA		■	■	■			■	▨	▨	■	▨	■			
RICHFIELD	■	■	■	▨	■	■	■	■				▨	■	■	▨
ROCHESTER	▨	■	■	■	■		▨		▨		■	▨	■	■	
ROSEVILLE	■	■	■	■				■							
ST. CLOUD	■	■	■	■											
ST. LOUIS PARK	■	■	■	■	■	■		■	■		■			■	
ST. PAUL	▨	■	■		■		■	■	■	■	■	■			
STILLWATER	▨	▨	▨	▨											
VIRGINIA		■													
WEST ST. PAUL	▨	▨		▨											
WHITE BEAR LAKE	▨	▨	▨	■											
WILLMAR	▨														
WINONA	■	■	■	■	▨		▨	▨				▨			

■ ACTUAL

▨ PLANNED

Table 2.3. EDP Operations Environment for Minnesota Counties and Municipalities

		CURRENT	PLANNED
DATA CONTROL	Computer room security	0	0
	Data access security programming/control plan	1	4
	Formal EDP regulations and procedures	4	6
	Control processes and procedures for release of information to public	3	4
	Public participation in information security policies	0	0
DATA COMPATIBILITY & STANDARDIZATION	Standardization of data elements and codes	6	6
	Classification schemes	4	6
	Transfer or conversion tables	5	5
	Interjurisdiction standardization	4	6
DATA BASE DOCUMENTATION	Data dictionary – intra-city	1	5
	Data inventory	2	5
DATA SHARING	Private sources	4	5
	Other units of local government	8	9
	State	4	6
	Federal	1	3
SYSTEM INTEGRATION	Integrated system, subsystem, or application	3	4
GEO-CODING	Dual independent map encoding DIME	0	0
	Address coding guide ACG	2	3
	X-Y Coordinate system (specify)	0	1
	Parcel number system	6	7
TRANSFERABILITY OF APPLICATIONS	Software	3	4
	System Design	4	5
SPECIAL FEATURES	On-line	1	6
	Interactive modes	0	2
	CRT	3	5
	OCR	2	4
	Plotters	0	2
	Line printer graphics	1	1
	Real-time process control	0	3

Table 2.4. EDP Training for Minnesota County and Municipal Personnel

PERSONNEL		TRAINING PROGRAMS IN-HOUSE	FORMAL COURSE-WORK IN SCHOOLS	COMPUTER INSTITUTES, SYMPOSIA,& CONFERENCES	MANUFACTURERS' TRAINING PROGRAMS
EDP PERSONNEL	EDP ADMINISTRATORS AND SUPERVISORS	2	2	3	7
	SYSTEMS ANALYSTS AND PROGRAMMERS	3	3	4	8
	OPERATIONAL SUPPORT, E.G., EDP CLERKS, ETC.	4	2	2	6
	EQUIPMENT OPERATORS	11	3	2	7
NON EDP PERSONNEL	ELECTED OFFICIALS	2	0	3	
	TOP MANAGEMENT AND DEPARTMENT HEADS	2	1	3	
	PROFESSIONAL AND TECHNICAL PERSONNEL	2	1	3	
	OPERATING AND CLERICAL PERSONNEL	4	1	1	

of this report. MINCIS is a computer-based system established for the State Bureau of Criminal Apprehension to serve local law enforcement throughout the State. It switches messages among all law enforcement teletype machines in the State – presently 161 – including all sheriffs, many municipal police departments, the Minnesota Highway Patrol, and certain other law enforcement agencies. It is also linked to the National Crime Information Center computer at the FBI in Washington, D.C., and to the National Law Enforcement Teletype System in Phoenix, Arizona. MINCIS automatically services requests for information on drivers license, motor vehicle registration, and stolen property. In the near future, many additional capabilities will be available through the system, principal among them being inquiry against a large and comprehensive criminal justice name file, both state and nationwide. Figure 2.1 shows the geographical distribution of law enforcement agencies serviced by MINCIS.

A system to accomplish these tasks should be State-based since the files are State-based. Any effort by a local government, even a large one such as Hennepin County, to establish a system with such capabilities would be unnecessary expenditure of public funds.

The importance of MINCIS to this discussion is two-fold. First, there might be additional systems that could be most effective on a statewide basis or a regional or other basis. For example, the State Department of Education has a statewide teacher personnel file which might be able to serve school district needs, rather than each district or each combination of districts establishing duplicative systems. Second, the MINCIS network is an established fact, a working demonstration in Minnesota that computer-based information systems are viable. Further, its existence may have a good effect on the cost of communications because of the possibility of line-sharing. Communications line cost are material factors in any effort toward cooperative development as clearly outlined in Part IV of this report. The more need there is for communications, the more opportunity there is to reduce the line cost per unit of output.

Minnesota School Districts

General Situation

Information systems and computerization in Minnesota elementary and secondary schools are just in the beginning stages. The school districts, like other jurisdictions, have realized the need for automation to help them keep pace with the large volumes of data that must be collected and maintained on students, teachers, and other employees, as well as physical plants and supplies. Some effort also is being made in the use of computers for instructional purposes: computer-assisted instruction, computer-managed instruction, problem solving, etc.

On the administrative side, the functions receiving the most attention are class scheduling, grade analysis, class lists, attendance, and payroll. Much of the actual data processing in these areas and in other areas is being done at outside data processing service organizations. Most of the work being done in-house is being processed by second generation equipment. Instructional use is generally based on commercial time-sharing systems.

State Department of Education Initiative

The State Department of Education has a concern unique among State agencies for the local government scene. This concern reflects the department's need to obtain information from the school districts and its responsibilities for assisting school districts in qualitative aspects of education. The State Legislature has a significant interest also because a large part of State revenues are appropriated in support of elementary and secondary education.

Although the scope of this study precluded a detailed review of the information systems and other computer needs of Minnesota school

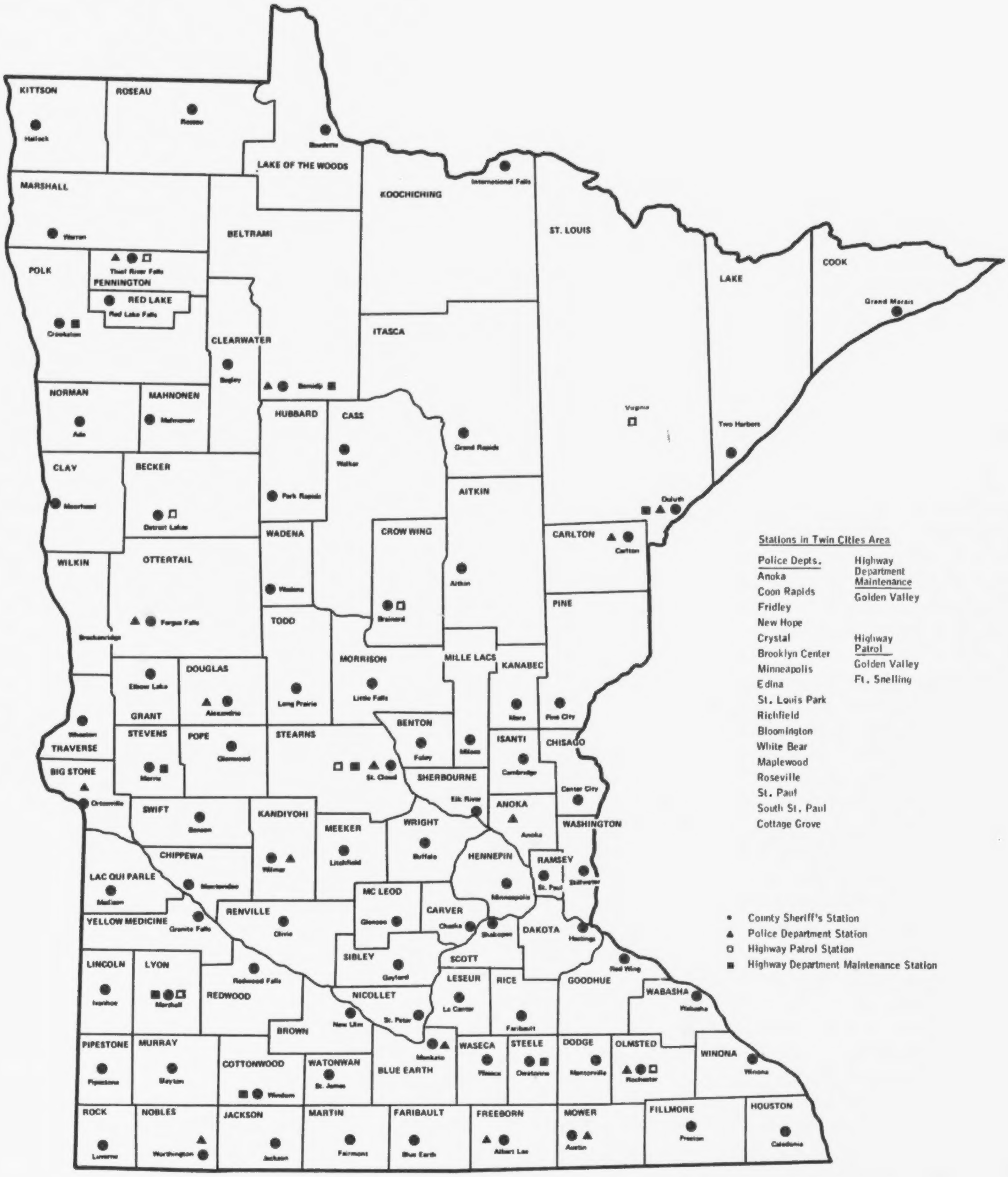
KITTSON
ROSEAU
LAKE OF THE WOODS
KOOCHICHING
MARSHALL
BELTRAMI
ST. LOUIS
LAKE
COOK
POLK
PENNINGTON
RED LAKE
CLEARWATER
ITASCA
NORMAN
MAHNONEN
HUBBARD
CASS
CLAY
BECKER
AITKIN
WADENA
CROW WING
CARLTON
WILKIN
OTTERTAIL
TODD
PINE
DOUGLAS
MORRISON
MILLE LACS
KANABEC
GRANT
BENTON
ISANTI
TRAVERSE
STEVENS
POPE
STEARNS
CHISAGO
BIG STONE
SHERBOURNE
SWIFT
KANDIYOHI
MEEKER
WRIGHT
ANOKA
WASHINGTON
CHIPPEWA
HENNEPIN
RAMSEY
LAC QUI PARLE
MC LEOD
RENVILLE
CARVER
YELLOW MEDICINE
DAKOTA
SIBLEY
SCOTT
LINCOLN
LYON
REDWOOD
LESEUR
RICE
GOODHUE
NICOLLET
WABASHA
BROWN
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON
Stations in Twin Cities Area
Police Depts.
Anoka
Coon Rapids
Fridley
New Hope
Crystal
Brooklyn Center
Minneapolis
Edina
St. Louis Park
Richfield
Bloomington
White Bear
Maplewood
Roseville
St. Paul
South St. Paul
Cottage Grove
Highway Department Maintenance
Golden Valley
Highway Patrol
Golden Valley
Ft. Snelling
● County Sheriff's Station
▲ Police Department Station
□ Highway Patrol Station
■ Highway Department Maintenance Station

Figure 2.1. The Geographical Distribution of State Law Enforcement Agencies Served by MINCIS (Minnesota Crime Information System)

districts and their elementary and secondary schools, a general review was made possible by three reports mentioned below, by discussions with education personnel at both local and State levels, and a brief study of TIES. Furthermore, the analysis of the Area Vocational-Technical Schools made in the higher education portion of the report is relevant to this part of the report since these schools are administered by the school districts.

The two reports referred to are "Characteristics of a Network Model for Regional Information Systems for Minnesota Elementary and Secondary School District"[4] and "A Study for the Coordination of Education Information and Data Processing from Kindergarten through College",[5] both prepared pursuant to a Federal grant for the Department of Education. The first of these contains a description of information systems, the inter-educational and intergovernmental relationships of educational information systems, organization required for a regional information system, and network implementation policies and plans. In summary, the report recommends the establishment of not more than seven nor less than four regional education information centers under the "immediate jurisdiction of the State Board of Education"; that the "TIES model be adopted and utilized for the development of the regional centers;" that developmental cost be assumed by the State; and that a number of steps toward implementation be taken.

The second report includes a summary of and selected excerpts from the (Minnesota) Governor's Conference on Computers in Education held in September, 1968; a status report on electronic data processing in education in Minnesota; and the first report discussed above. The Governor's Conference was held under the sponsorship of the Minnesota Council on Educational Information Systems (MCEIS) which is composed of 26 public and private agencies concerned with education. The status report was initiated by a planning group which later developed into MCEIS. The second report essentially supports the first report, along with presenting a report on national trends and the then (1967) status in Minnesota.

In September, 1969, a third report was issued which has direct bearing on educational information systems. It is titled "Preliminary Report for Development of Minnesota Educational Service Areas (MESA)".[6] It is a product of the consultant staff of the Division of Planning and Development of the State Department of Education. The report proposes the establishment of eleven MESA's (educational service areas) in Minnesota, coinciding with the eleven regional planning areas of the State. Among many other services to be performed by each MESA would be "data processing" and other functions requiring information system capability, such as pupil and teacher personnel services. The report has not been acted upon by the Board of Education although under active consideration by the Board.

Another report, prepared by ARIES, proposed a plan for information systems and computerization for the AVTS system. As pointed out in the higher education portion of the report, a central facility with remote terminals was recommended. It is emphasized, however, that the ARIES study was limited solely to AVTS; and its recommendations are in that context.

Level of Awareness

Discussions with State and local educators disclosed a strong interest in information systems and computers as applied to local government. There is an awareness both of the needs and the problem associated with solving the needs. The evidence, however, suggests that the needs are more fully understood than the problems. Some school districts of modest size are embarking just now on their own on programs which will inevitably follow the pitfall laden path outlined early in the next section of this part. There appears to be little understanding of the necessary management involvement and virtually no grasp of the sizable dimensions of the task. The two largest school districts, Minneapolis and St. Paul, each also going it alone, are in the beginning stages of computer development efforts that will require several years and many hundreds of thousands, if not millions, of dollars to get to the operational level required for full-scale information systems and instructional use.

State Board of Education Action. In July 1970, the State Board of Education enacted the following policies on recommendation of the Commissioner of Education, clearly evidencing the Board's interest in and concern over the problem.

- The regional concept of educational information centers is the best method for satisfying the elementary and secondary educational information needs of the State.
- The elementary and secondary education information system is an integral part of a statewide educational system.
- Existing organization models (such as TIES and Area Vocational-Technical Schools) should be reviewed and considered as organizational alternatives in the development of regional centers.
- The elementary and secondary schools of the State are encouraged to utilize the higher education computer system for academic purposes to the extent feasible.
- A committee is to be created to assist the State Board and State Department of Education in policy, planning, development, implementation, coordination, and evaluation of the system which would place major emphasis upon compatibility of a data base, hardware, software, and informational reporting.
- No regional center should be designated until a statewide information system study is made.

In short, there has been consideration given to cooperative effort in educational information systems and other educational computerization in Minnesota. The machinery for such effort is available in Minnesota; an example of its use which has potentially far-reaching implications for local government follows.

TIES

Minnesota has one of the leading examples of local government cooperative development of information systems and computerization in the country. In 1967, acting under the Minnesota Joint Powers Act, twenty school districts in the Twin City Metropolitan area agreed to undertake an effort in the development and operation of computer systems. The organization, named TIES (Total Information for Education Systems), began its developmental work in September 1967. Since then it has grown to include 29 school districts including one outside the metropolitan area, Willmar, Minnesota. These school districts serve approximately 240,000 students and have nearly 29,000 employees. TIES is controlled by a Board of Directors composed of one representative from each school district. An active Executive Committee of the Board is close to the TIES operation. The 1969-1970 year was TIES first operating year. Only limited applications were available in the 1967-1969 development period.

To assist during its development, TIES, with help from the State Department of Education, obtained Federal assistance for a three-year period. The school districts also helped fund TIES during this period. As of July 1, 1970, all funding is coming from the school districts and is pegged in the July-June 1971 fiscal year at $5.00 per pupil. In addition to this, each school district incurs substantial additional expense, mainly the salary of a TIES coordinator, remote terminals, and communication costs.

TIES' charter is to provide full scale information systems and other data processing services for administration of the school districts. It is also to provide a computer base for instructional and research use. Table 2.5, based on a recent report on TIES, shows the initial plans of TIES and the present status. In addition to information in Table 2.5, TIES has made a successful start in the instructional area. Using a Hewlett-Packard 2000A computer with a relatively small memory (16K), TIES provides a time-sharing service to 47 remote teletypes in its school districts. The

Table 2.5 TIES (Total Information for Education Systems)

DATA CONTROL SYSTEM

* Data Management
* Inquiry
* Batch Control
* Update
* File Control Program
* Inclusion of Teletypes

STUDENT INFORMATION SYSTEM

* Scheduling 1969-70
* Mark Reporting 1969-70
* Scheduling 1970-71
* File Conversion
* Test Scoring Trailer Inclusion

PAYROLL-PERSONNEL SYSTEM

* Initial Payroll System
● Personnel Payroll System
● File Expansion

(p) CENTRAL STORES

(p) PROPERTY ACCOUNTING

BUDGET-FINANCE SYSTEM

● Revenue-Expenditure Accounting
● Accounts Payable-Purchase Order Processing
● Planned Program Budget System – Conceptualize

CENSUS/ATTENDANCE SYSTEM

* File Conversion
* Enumerator Document Preparation

(p) EDUCATIONAL MEDIA – Audio Visual, Library, Subject Reference Generalized Extract for Requested Reports

(p) Initial Payroll Files
(p) All System Files

TEST SCORING

● Standardized Test Scoring
● Teacher-Made Test Scoring

PROBLEM SOLVING

* Implementation of BASIC – Conversational
* Implementation of BASIC – Batch Mode
● Problem Processing – FORTRAN, Batch Mode
* Problem Processing – COBOL, Batch Mode

*** SIMULATION – GAMES**

STATISTICAL PACKAGE

(p) Analysis and Development – STATPAC
(p) Testing and Implementation

ACHIEVEMENT MONITORING

● Establishment of Objectives
● Testing of Objectives and Validation
● Student Analysis and Prescription

* Initial
● Acquired
(p) Planned

system has facility to assist with programmer training, arithmetic computations, and some simulations. The instructional capability is scheduled for considerable expansion in the near future.

Table 2.5 and a list of the instructional applications give a good indication of the complexities involved in developing adequate information systems and computer capabilities for school districts. Extremely sophisticated systems design and programming are required. A development effort of this nature — whether for one school district or many — is staggering in terms of time, money, and management involvement.

TIES has not been without its troubles. As just stated and repeated for emphasis, any computer development of this magnitude is tremendously complex. A June 1970, report of an evaluation of TIES details the history of TIES development and its many problems.[7] The evaluation report should be read by anyone interested in successfully implementing cooperative computer efforts in Minnesota. The report contains an "overview" page which reads:

> In its first year of operation, TIES has damaged its image and disappointed many of its users. It has also produced some notable accomplishments — an integrated data base and remote problem solving by students. Most notable is its ability to serve 29 separate school districts by means of a centralized computer system. . .a pioneering feat in educational data processing. TIES has also effected many repairs and is restoring the confidence of its users.
>
> By means of strict adherence to system development discipline, TIES can continue this upward trend and move to new levels of service.

The school districts in TIES have available now, and increasingly so in the future, information systems and other computer facilities far beyond what they could have developed in the same period and at a small fraction of the cost they otherwise would have incurred. It appears highly probable that the TIES school districts will have such facilities much sooner and much more comprehensively than the two largest school districts of the State or any other "go it alone" districts.

CHAPTER 4

STRENGTHENING INFORMATION SYSTEMS AT THE LOCAL LEVEL

Much of the information that would be helpful in planning and operating governmental programs exists at the local level. Therefore, a crucial factor in achieving an effective flow of information is the capability of local governments to collect and produce the information in a timely and systematic way.

It is a sobering fact that information systems operated by local governments frequently are not in tune with today's needs. In general, they fall short of satisfying the requirements of local officials and of State and Federal agencies and, most certainly, are seriously deficient in providing essential information regarding the local environment.

There are several reasons for this. Innovative attempts to improve these systems are often frustrated by political, organizational, financial and legal considerations. Added to these frustrations is the burden of information requests from State and Federal agencies, whose uncoordinated demands (discussed in previous chapters) sometimes confound the situation even more.

Of major importance also is the fact that most local governments do not have the professional expertise and the technical capability to cope with the rising complexity of information requirements. Not only does this impede progress, it leaves local officials without an objective appraisal of proposals from commercial suppliers of systems and computers, whose optimistic promises may raise false hopes and lead to expensive failures.

The present inability of local governments to escape unscarred from the shackles of outdated methodology severely jeopardizes the prospects for their effective participation in the structuring of information helpful to their own development. The need to strengthen the capability of local government in this process is, therefore, a matter of higher priority. Fulfillment of this need will facilitate truly intergovernmental approaches to the solution of public problems and will help insure a proper balance among the levels of government.

10. **Recommendation:** Pool the resources of local governments to launch a program of mutual assistance in upgrading local information systems.

Most local governments cannot hope to improve their system capability in any dramatic or progressive fashion if they act independently, because their own resources are usually much too limited.

The Task Force believes, however, that local governments can accomplish much if they act together. There are instances where several contiguous municipalities have already joined forces to study possibilities for sharing the costs of designing new systems in areas of common interest, and of operating the systems through shared computer facilities. Such cooperative efforts not only spread the initial cost of systems development among several local governments, but they also potentially provide each government with a systems and computer capability which it could not justify or support financially on its own. Local governments should be alert to these possibilities and seek to capitalize on them whenever feasible.

3. APPROACH TO LOCAL GOVERNMENT INFORMATION SYSTEMS AND COMPUTERIZATION

As has been shown in the previous sections, developments in systems analysis and computerization in local governments are occurring at a rapid pace throughout the country. There is a substantial body of knowledge on the subject, much of it in a research form rather than applied.

The need to bridge the research-application gap can hardly be overstated. Economic and political pressures discussed in Part I and elsewhere in this report are forcing local governments to use all tools at their command to increase their cost effectiveness. Unless viable alternatives can be designed and implemented, local governments will go their own way.

POTENTIAL PITFALLS

The typical sequence of events that has been experienced as a local government moves to computerization runs along these lines:

1. A computer feasibility study is performed, usually by persons with little or no systems or computer background, sometimes assisted by a computer vendor, and occasionally with the help of a consultant.
2. The study is generally limited to, or at least heavily weighted in favor of, one or more major or "pet" applications and does not go to the question of overall information systems design or implementation. In fact, there generally is forthright recognition that "this will at least get us started."
3. A computer selection is made, sometimes on a totally objective basis but sometimes on the basis of vendor assistance. But it is always made on the basis of "what the government can afford," not what it needs. In fact, the study itself is ordinarily bound explicitly or implicitly by that consideration. The result generally is that a local government "gets started" on a base of a computer that is not geared to its overall needs, cannot do a satisfactory information systems job, and will surely lead to extensive and expensive reprogramming in a year or two.
4. The next thing following placement of an order, not often prior thereto, is a frantic search for one or more programmers. They are generally found but often only by paying a higher than going rate. Small installations with small computers are not as attractive to good programmers as larger installations with more advanced applications and memory sizes permitting optimum programming.
5. The programmer then generally proceeds to do what needs to be done first — namely, design the systems to be programmed. But often he has no experience or at best, limited experience, in systems design and only infrequently does he have experience in government. In addition, almost always he is expected to produce results in an unrealistic time frame. There are three principal reasons for this. First, the administrative personnel advancing computerization have generally had no experience in designing, programming, and implementing computer systems and are led down the seductive, primrose path of the "just put it on the computer" world by vendors or consultants. Second, the programmers generally lack heavy experience in project design, estimation, and management, and are typically highly overly-optimistic. Third, conversion of operations to the new system is generally poorly planned — if indeed it is planned at all.
6. The general result is that time tables are missed; budgets overrun, often catastrophically; and results even when accomplished inadequate and disappointing. Frequently, results are

obtained only by herculean efforts on the part of the programmers, etc., and often leave a trail of personal animosities between the "implementers" and the "implemented."

7. Progress is ultimately made although generally far short of expectations, and a computer application — such as utility billing, payroll, assessment records — is there for all to see. But almost never has it real relevance to an information system. Further, the length of time that passes between the feasibility study and the implementation and operation stage is often measured in years rather than months, in time overruns of 200 and 300 percent.
8. At some point, a re-evaluation takes place. If the environment is correct, the second time around may lead to a vastly improved situation. But the chances are that the result will be a slightly larger computer (still not large enough for the total needs), with most effort being to re-program existing and inadequate systems to the new computer without the development of the necessary data bases and information systems.
9. When the cost/benefit is calculated (if it ever is), watch out. Typically, many years have passed, and some efficiencies may have finally resulted in the heavy clerical areas; but the information systems do not exist.

This description is, of course, not universally true in each detail. But it is painfully close. It is certainly close enough so that it will support a generality that the taxpayers of Minnesota will not support a continued proliferation of relatively unsuccessful, non-integrated, extremely costly computer efforts in the 87 counties, and the hundreds of municipalities and school districts.

As indicated earlier, however, irresistible forces are moving local governments toward computerization. Admonitions and various and sundry "Thou Shalt Nots" will be ineffective in the absense of alternatives.

BASIS FOR ALTERNATIVES

If agreement can be reached on certain objectives, principles, and policies, selection from among possible alternative approaches to information systems development in local government may be simplified. The following is intended to lay the groundwork for such agreement.

1. Among the leading objectives of local government in the immediate future is the installation of information systems for each governmental service program. These information systems are to have the characteristics outlined early in Section 2 of this part of the report, most especially the ability to interrelate.
2. Local government information systems requirements as called for in (1) above, are so complex as to demand the services of highly qualified systems analysts and to require medium or large scale computers. Even for a relatively small local government, the management of several on-line files requires substantial computer capacity. Programming becomes more complex, and the system must have the ability to handle more than one application or procedure at the same time. Substantial high-speed memory size is indicated. Further, large random access storage devices are essential.
3. The advantages that accrue with sound systems, the larger computers, and communications technology make economically feasible now to most local governments, and in the future to all, the sophisticated systems referenced in (1) and (2) above.
4. The computer is a tool which, like the telephone, is to be available as needed. Physical control over it, or ownership of it, is unimportant. What is important is its availability and its ability to do what needs doing. In short, the computer is too expensive to serve as a status symbol.
5. The computer itself has no idealogy. It is a political eunuch. It argues neither for

more or less centralization, decentralization, regionalization, integration, disintegration, or any other direction or trend in local government organization. It can serve any trend. It is indeed analogous to the telephone system: a tool to be used as the user wants to use it.

6. Systems analysis and design requires dedication of highly competent specialists from the various agencies and fields of government, as well as systems experts, to assure information systems with sufficient flexibility to meet requirements. Again and again in the State part of this report, the crucial nature of this task was emphasized. Where comprehensive information systems are the objective, systems design addresses the scope of the executive's job so as to build into the design the information needed for decision-making – and in some cases to automate part of the decision-making system itself. Further, systems analysis of a function covers all characteristics of that function, not only those aspects that might be computerized.

7. Both the operating and the management requirements of information systems in the same level of local government – such as school districts – vary little from jurisdiction to jurisdiction. Differences are mainly a matter of size or emphasis. As a result, the joint development of information systems is practical. This principle is in evidence in many jurisdictions, both public and private. Specifically, it is demonstrated in the State's MINCIS program and in the many TIES applications. Further, the burden of proof for not using a jointly and carefully developed system should be on the jurisdiction choosing not to use it.

8. Assuming properly documented systems design, quality programming can be best accomplished where competent programmers and programming management exist. In other words, whereas it is crucial that local governments participate heavily in systems design, the programming effort is of no concern to a particular local government so long as the system works.

9. Corollary to (4), (7), and (8) above, is the fact that management of computer operations is a specialized and extremely complex field. If possible, local government administrators would be well advised to leave the often complex administration of the computer function to specialists. The time of program administrators can be spent far more productively in program administration than in becoming involved with the frequent and demanding problems of computer management.

10. Costs of computer operation can be charged to users with reasonable accuracy on the basis of use. The costs of systems analysis and initial programming call for investment of funds on some equitable basis.

11. Applications resulting in cost reduction or cost avoidance can ease the financial stress and thus earn some degree of priority. Careful scheduling and planning will assure subsequent, economic integration of such applications with their related information systems.

12. Conversion planning, often almost an after thought, is a fundamental requirement of successful systems implementation. Many well planned systems have barely survived disaster or have failed completely because the users were ignorant of or underestimated conversion requirements.

13. Intergovernmental needs for information have a strong bearing on systems design and to some extent on computerization itself.

It is suggested that general understanding of and support for the foregoing propositions can lay a proper foundation for information systems and computerization development in Minnesota. The opportunities for coordinated, cooperative implementation would be clear.

COST/BENEFIT

Analysis of direct and indirect cost/benefits of information systems and computerization as discussed in Part I of this report would in all probability be virtually impossible in most Minnesota local governments at this point. It has already been indicated that it was not possible to conduct such analysis at the State level. In the main it remains to the future to determine the cost effectiveness of both existing and planned operations. Such determinations are dependent upon sound cost accounting data and professionally-conducted feasibility studies.

What can be said, however, is that there is enormous cost/benefit potential in future local government information systems and computerization development. That is, if a small computer installation carrying out limited applications without the ability to manage a number of information systems for the services of government is cost effective, then it can be said that a properly organized and administered large computer installation can produce far greater cost/benefit.

To put it another way, for those local governments that are serious about embracing the concepts outlined early in Section 2, the costs for all except perhaps the largest of local governments are presently prohibitive if attempted alone. The cost/benefit advantages of cooperation and coordination are overwhelming. In summary, these savings accrue from the economies of scale as related to the computer itself; elimination of the enormously costly redundant efforts in systems design and programming; and most importantly, the planning, management, and operating assistance provided by the information systems.

Whether those advantages are generally realized remains to be seen. The degree that they are realized will be a measure of the statemanship of the elected officials and the competence of their appointees. As time passes the absence of comprehensive information systems will become more and more costly both in terms of the loss of direct cost/benefit and in terms of the quality of life.

It has been said before and is stressed again here that the development of information systems and their successful implementation are complex, time-consuming tasks. Several years and substantial sums of money are involved. The costs, however, of the half-way or do-nothing alternatives and the go-it-alone approach are intolerable.

4. RECOMMENDATIONS

That local governments stand in need of improving the quality and minimizing the cost of their services has been emphasized throughout this part of the report. Information services and computerization have been advanced as tools – perhaps the most important tools – to assist in the improvement. The question addressed in this section is how can this best be done.

In Minnesota, with a handful of exceptions, the accomplishment of the local government information systems task as outlined herein makes virtually unavoidable some sort of cooperative approach to the problem. The economic realities cannot be avoided; they are discussed at some length in Parts III and IV of this report. The Institute of Public Service at the University of Connecticut summarizes them this way:

> In general, computing power increases more rapidly than the square of the price; in other words spending twice as much money gives 4 to 5 times the computational power, 4 times the money gives 16 to 20 times the power.
>
> By operating a computer center on a three-shift (24 hours) basis, instead of a one-shift (8 hours) basis, hourly costs for the computer drop substantially. For example, computer equipment costing $100 per hour if operated one shift, costs only $40 per hour if operated for three shifts.
>
> Expanding a small computer configuration into a larger computer configuration requires substantial reprogramming costs. Significant "payoffs" from use of computers is dependent upon sufficient investment of funds in computer systems' design. Operating independently, most Connecticut communities are only able to invest relatively small amounts of resources. The result is a marginal return on investment.[8]

Perhaps even more important are the advantages gained by pooling personnel resources. Finally, it is again emphasized that full scale information systems call for sizable computer facilities. Input from and output to remote terminals; on-line updating of computer files; real-time processing and retrieval of information; and communications capabilities to service the foregoing will be required.

Thus, on the subject of information systems and computerization, local governments – counties, municipalities, school districts – stand at a crucial crossroad, or perhaps more aptly, at a jungle of super highway interchanges. Standing with them are the Federal and State governments who have a large measure of dependency on local government. For it is largely at the local levels that Federal and state programs are administered, and it is largely on information (or lack of it) from the grass roots that Federal and state legislation and policy are established. Watching from a slight distance are the Legislatures since local governments are creatures of the State and because much of the State budgets goes to local government.

The first decision to be made is whether Minnesota local governments, in general, seriously desire information systems. Do they understand and are they willing and able to cope with the implications of information systems? For example: the ability to evaluate program results with all that such ability implies; the data with which to compare operating costs with other similar jurisdictions; the need to take on the tough task of specifying unequivocal objectives; the need to look upon the computer as a tool and not a status symbol; the ability to establish the policies necessary to the introduction and implementation of information systems.

The foregoing are fundamental points requiring careful consideration by county boards, city councils, and school boards and by their top administrative officials. The information systems

— computerization game cannot be played by a simple decision to mechanize. What this report is all about is not installing a payroll system on a computer. Rather it is about systematizing and computerizing the operations of governments and insofar as feasible, their decision making processes. Information systems require statements of objectives, programs, and policies as the starting points.

There follows a series of recommendations and guidelines to serve as a plan for accelerating the efficient development of local government information systems and computerization in Minnesota.

They are in these groupings:

- General recommendation for State policy
- Organizational requirements
- Approaches to cooperative centers
- Area Computer Centers
- Orientation and training
- Funding
- Implementation suggestions.

GENERAL RECOMMENDATION

The general needs outlined herein are widely recognized. Catalytic action is required, however, to set the stage for meeting the needs. Such action was almost initiated by the 1969 Legislature; it is the strongest recommendation in this report that the Legislature enact at its 1971 Session effective legislation on local government information systems and computerization.

> In summary, it is recommended that the Legislature establish an Intergovernmental Commission on Information Systems with coordinative authority over all cooperative efforts in local government information systems and computerization. The authorities and responsibilities of the Commission are limited to those necessary to attaining a coordinated, statewide approach to the building of local government information systems and to establish the framework for the orderly and efficient development of cooperative computer facilities. Implementation of this recommendation would call for amending the Minnesota Joint Powers statute (a) to require as a final step, insofar as information systems and computerization are concerned, approval by the Intergovernmental Commission, and (b) for such joint efforts, involving any school district the approval of the State Board of Education prior to Commission action. In addition, *developmental funding* by the State on a matching basis with local government is recommended as is Commission control over Federal, State, or foundation funding for all local government information systems and computerization *developmental efforts.* It should be noted that the recommendations are limited to cooperative and coordinated activities. "Go it alone" efforts by local government are not recommended to be in the purview of the Commission although such efforts may be affected by Federal or State requirements. More specific details of the recommendations, guidelines for their accomplishment, and implementation suggestions follow.

ORGANIZATIONAL REQUIREMENTS

A formalized organization structure must be established in order to provide the framework and the machinery for orderly development of local government information systems and computerization. Four specific recommendations follow. The alternatives are discussed in each case along with the reasons for the recommendation.

Intergovernmental Commission on Information Systems

Responsibilities and Authority

Some body concerned with the overall development of local government information systems and computerization is necessary. In a situation so complex and involving so many different governing bodies, several levels of government, and diverse subject matter areas, effective coordination is hard to attain spontaneously. TIES is an example where excellent coordination was attained, an accomplishment without parallel in Minnesota and perhaps nationally. But TIES had a number of favorable factors working for it (geographic centrality, common subject matter, and federal funding being principal ones) which may not always be present. It would be unrealistic to trust to a series of TIES-like development throughout local government in time to meet the problem. Further, TIES alone cannot bring about the statewide standardization in data elements, etc., necessary for compatible and transferable systems.

Another alternative is to urge the State Board of Education to move ahead on its own with TIES-like developments under MESA (Minnesota Educational Service Areas) or a similar regional breakdown, leaving other local governments either to their own devices or placed under some umbrella agency that is not concerned with school districts. But there is a real need to coordinate school district information systems development with all other local government systems. Standardization in data elements among all jurisdictions is the basic requirement for interchangeable data. There is also a need to assure most effective utilization of personnel and equipment statewide.

The recommendation of this report is that an Intergovernmental Commission on Information Systems be established with coordinative authority over cooperative efforts in information systems and computerization in local government. Only in this way will it be possible to look at the entire problem in a manner that can maximize the cost effectiveness of such efforts. It is recommended further that State Board of Education approval be required for any joint effort of this nature on the part of school districts, prior to submission of the plan to the Intergovernmental Commission. It is believed that through these two steps the statutory responsibilities of the State Board may be met and the necessary coordination will be obtained through the Commission.

The authorities and responsibilities recommended for the Commission must include *only* those necessary to permit statewide coordinated efforts toward compatible information systems and to assure carefully planned development of computer facilities throughout the state. In addition, the recommended representation on the Commission is designed so as to assure an effective voice for all groups. For example, educational representation is such that all decisions will have ample input from school district interests. With the Commission, all options on methods of cooperation and coordination are left open; and in addition, the need for standardization may be met. The recommended responsibilities and authorities of the Commission, limited to those necessary for efficient coordination, are:

1. To establish goals and objectives for intergovernmental information systems in Minnesota as well as general policies governing coordination, cooperation, joint efforts, and priorities.
2. To authorize establishment of Area Computer Centers; to promulgate policies and procedures assuring the coordination of the efforts of Area Computer Center Boards, so that an integrated statewide system may ultimately be developed; to establish (a) criteria for determining economic feasibility for the Centers and the several information systems, and (b) procedures for measuring actual versus expected cost/benefits.
3. To coordinate the development and implementation of standards of compatibility of procedures, programming languages, codes, and media to facilitate the exchange of information within and among systems.
4. To review and approve or disapprove all applications requesting Federal, State, or foundation funding for planning and development of programs with potential impact on local or intergovernmental information systems.
5. To review and comment upon policies affecting intergovernmental information exchange established by the Governor's Committee on State Information Systems and/or the Director of Information

Systems and provide advice to the State on long-range policies, programs, and plans relative to intergovernmental information systems.

6. To develop policies and design procedures for the security of data in local government information systems and safeguarding the confidentiality of such data consistent with state statutes, local ordinances, and pertinent administrative rules and regulations (also see recommendation in Part III on security and privacy).

It is expected that until the establishment of this Commission, the State-Local Data Systems Group, discussed in Section I, will be working toward the same general objectives.

Revision of Joint Powers Statute

The Minnesota Joint Powers statute has served well as the vehicle for permitting cooperative efforts between and among local units of government. It would serve as the base for future cooperative efforts in information systems as it did for TIES. It is recommended, however, that the statute be revised to require approval of the Intergovernmental Commission on Information Systems prior to establishing any future cooperative effort in information systems and computerization and that any such joint efforts involving school districts be subject to approval by the State Board of Education prior to Commission action. The reason for this recommendation is that the coordinated and efficient development of a statewide information system has to be accomplished within some general framework as discussed in more detail later – economic feasibility, geographic considerations, etc. Only the Intergovernmental Commission will have this viewpoint. If this is not done, it will be virtually impossible (a) to avoid the overwhelming cost of redundancy, and (b) to develop standardized and compatible information systems.

Intergovernmental Commission Membership

In order to attain a true intergovernmental base, members of the Commission should represent all governmental echelons involved with intergovernmental information requirements. Majority representation, however, should be given to local governments as a group. Accordingly, it is recommended that the Commission membership should consist of two persons representing counties, two representing municipalities, three representing school districts, three representing the State government, and one each from the Governor's Committee on State Information Systems and Minnesota regional government. The State members should be the Director of Information Systems, a representative of the State Board of Education, and a representative of higher education. A Federal observer should be obtained from a department such as HEW or HUD that is heavily involved with intergovernmental information. Thus, local government would have seven of the twelve members; school districts would have four, including the Board of Education representative; counties and municipalities would have a total of four.

It is further recommended that the appointments be made by the Governor, to serve at his pleasure, and that local government representation be made from nominations submitted by the Association of Minnesota Counties, by the League of Minnesota Municipalities, and jointly by the Minnesota School Board Association and the Minnesota Association of School Administrators. Finally, it is recommended that the State Director of Information Systems be chairman.

Local Government Division

The Intergovernmental Commission must have an effective staff to carry out its heavy responsibilities. One approach would be to develop a separate and independent staff to implement its program. A second approach, and that recommended herein, is to use the staff of the Local Government Section of the Division of Information Systems. The advantages of this recommendation are that (a) the necessary interfaces with state agencies will be more readily attainable, (b) staff costs will be minimized, (c) staff specialists from the Division of Information Systems will be more readily available and more effectively used, and (d) the relationship between the recommended chairman (Director of Information Systems) and the staff should be most effective. The disadvantage is the possibility that the State's interests may be given undue weight, a possibility that the Commission itself should be able to control.

The Local Government Section, then, would have as its primary responsibility serving as staff for the Intergovernmental Commission on Information Systems. As discussed later, it would also be closely involved with the Area Computer Center Boards, particularly in systems development and standardization efforts, and would work closely with the EDP Coordinators in those State agencies involved with local governmental functions, such as the Departments of Education and Welfare. (Note that a Local Government Unit began operations in the State Computer Services Division in July 1970.)

Area Computer Center Board

Among the duties recommended for the Intergovernmental Commission were authorizing the establishment of Area Computer Centers and promulgating policies and procedures assuring coordination of the efforts of the Area Computer Center Boards. The centers, then, would be authorized by the Commission and would be operated by the Area Computer Center Board under broad policies established by the Commission to assure integrated, consistent, and economical systems analysis, programming, and computerization efforts. Without this, there would be no assurance of attaining any of the objectives discussed in this part of the report.

The Area Computer Center Board should be elected by the local governmental bodies involved with the Center. Since the demands of the Board may be substantial, the membership should be limited to a workable number such as seven. The Boards may, of course, appoint standing committees of an action or advisory nature. In the event that the computer base for the Area Computer Center is either temporarily or permanently a state, higher education, or AVTS computer center, the Board would be concerned with systems development and with the priorities and scheduling of the work of local government but not with the actual operation of the computer facility.

Systems Coordinators

Certain departments of the State government have supervisory or regulatory authority over certain local governmental functions. Where this is true and where State funds or Federal funds channeled through the State are involved, it is recommended that planned expenditure for developing information systems and/or computerization by such local governments for those particular functions must have approval of the related State agency prior to submission to the Intergovernmental Commission. Principal examples are the Department of Education and the Department of Welfare. The Systems Coordinator in the affected State agency should have responsibility for reviewing such requests. He is to assure that the development plan is consistent with State legislation and with the policies of the Intergovernmental Commission and his department prior to recommending its approval to his commissioner.

APPROACHES TO COOPERATIVE CENTERS

Alternate Methods

As indicated earlier, the only cost effective computer cooperation for most local governments in Minnesota means common use of systems and computers. The question is *how* best to do this. There are many alternatives, but they may be viewed as essentially of three types: geographically oriented, functionally based, or a combination or overlapping of the two.

A *geographically oriented* Area Computer Center would be based, for example, on a county or a combination of counties, or a State region. A *functionally based* Center would be limited to serving counties or more probably, school districts. A *combination* or overlapping situation would arise when all school districts in a State region formed one Area Computer Center and a second center is formed by all counties and their municipalities.

Location: Regional Base Preferable

Designating geographic boundaries and specific locations for each Area Computer Center is far beyond the scope of this project. In fact, it will be some time before quantitative criteria can be established for such decisions. A review of the general criteria mentioned later in this section gives some indication why this is true. In addition, and most important, the computer requirements of information systems for counties and municipalities are simply not known; comprehensive systems do not exist. There is better understanding of the information systems in school districts, but even that level of knowledge is imprecise. Furthermore, the instructional needs are not now quantifiable. It is simply not possible *now* to divide the State into "x" number of Area Computer Centers located in specified municipalities. But there *must* be a start in the development of centers.

Notwithstanding the foregoing, it is recommended that State regions designated in the Governor's Executive Order No. 60 be used as a basis for the *planning* of Area Computer Centers. As guidelines at this time, a Center should cover a full region, two or three regions, or a part of a region but not parts of two regions. The extent of coverage would be determined on the basis of the systems requirements and the criteria discussed later. One region might require more than one Center; two or more of the sparsely settled regions might be well served by one. The reasons for the recommendation are the probable development of regions in Minnesota as a service agency for both State and local government and the need for a reasonable base on which to begin the planning effort. As discussed in Section 2, the State Board of Education is considering the establishment of MESA's (Minnesota Educational Service Areas), based on State regions. Deviation from this recommendation should be permitted only after exhausting all possible alternative arrangements within the regional configuration.

General Criteria for Centers

Although specifying the quantitative criteria for the selection of an area for cooperative development was not a part of this study, the following are suggested as the major factors to be considered. Development of quantitative criteria is a major undertaking for the Intergovernmental Commission; it need not, however, delay implementation of at least two Area Computer Centers as recommended later.

Service Base. There must be a service base sufficient to justify the center. If the center is to serve all local government needs in its area, then a population criterion would serve as the service base. If, for example, school districts in the area are to be served another way, then the population criterion would have to be adjusted upward to reflect the loss of the school district function. There are no known criteria of this nature although one study has concluded that a center satisfactory for school district use only would require a base of 100,000 students.[9]

Utilization Capability. Related closely to Service Base above, is the general level of readiness to use the facility. Is the potential clientele in the service base able to make use of the systems and computer facilities? To some degree this is a function of orientation and education in computerization. It can be expected to be a much more important factor in school districts than in other local government jurisdictions because of the instructional uses. Such uses are almost totally dependent on the individual teacher's understanding whereas administrative uses are less dependent on one person. The need for curricula in information systems and computerization is emphasized later.

Financial Support. There must be evidence of ample financial support for facilities, processing, and overhead. It is anticipated that the developmental costs of systems analysis and programming will be funded jointly by State and local governments. The costs of updating the system and its programs after the initial implementation should be covered in the overhead expenses. (It is assumed that development will be accomplished centrally with costs distributed over all the centers. To the extent that this assumption is not accurate, higher costs will necessarily result.)

Contract for Service. Evidence of appropriate resources and continuity of service should be written agreements between the area center and the local governments involved, covering costs of providing each service desired. The contract must include agreement not only as to the services to be performed by the center but also the tasks to be performed by the user and the user's agreement to assign a qualified coordinator to represent the user with the center.

Geographic Location. The area covered will, of course, be a function of population density and local government participation. The time and cost of surface transportation for batch processing and the cost of common carrier lines for on-line processing are important factors in the feasibility of any specific geographical coverage. Although geographical contiguity is not mandatory, it is highly desirable and should be required except under extremely unusual conditions. Geographical compactness should normally be sought, and county lines should not be crossed unless to reflect a school district or a municipality in more than one county.

Communications Costs. In addition to their relevance to geographic location, communications costs are influenced by the information systems requirements. If most activity involves on-line operations, then telecommunications costs will be relatively low per transaction or per unit of throughput. If communication lines are little used, then their cost per transaction goes up.

It should be clearly understood that the preceding criteria are exceedingly dynamic; each of them is changing as a result of external forces or because of interaction with the other criteria. For this reason, precise measurement is not desirable even if possible. It appears likely that original demand estimates will inevitably prove to be low.

Area Computer Centers

Against the background of the preceding discussion, specifics of Area Computer Centers are now considered. There are three alternatives that appear to be feasible in Minnesota.

- **A Center created anew under authority of the Intergovernmental Commission.** An example of this type of Center is TIES, in which case twenty school districts set up a new computer center under the Joint Powers Statute, and employed the systems, programming, and operating staff to carry out all phases of development and operations.
- **A Center already existing in higher education.** Certain of the larger higher education institutions have or will have computer configurations with the capacity to handle information systems and computerization requirements of local governments including school districts. Provision of such service would be consistent with the institution's public service objectives. The development of instructional uses by such an institution could be most helpful to school districts. Depending upon developments in type and quantity of utilization over the next few years and the composition of the higher education network as discussed in Part IV of this report, the institution may find that it would be faced with a choice of serving only higher education, limiting its service to higher education in favor of serving local government, or greatly increasing its computer capacity.
- **A Center already existing in an AVTS.** No AVTS now has a computer configuration capable of handling the kinds of information systems and computerization called for in this report. In fact, most of the present computer configurations in the AVTS's are less than adequate for the educational needs of those schools because of their size and generation. The larger

configuration necessary for an Area Computer Center could fill the educational need. Further, the programming and operational requirements of a Center would offer substantial opportunity for excellent student training. The AVTS's, under school district control, are a logical choice to provide service to school districts and their schools. In addition, the AVTS's in many communities enjoy a close relationship with county and municipal governments.

Clearly, the first alternative is economically feasible only when the previously discussed computer center criteria are satisfied, in particular a large service base in a small geographic area. Even then, temporary use of an existing large computer configuration would normally be desirable until installed applications and volumes justify the separate installations. In most cases, however, the latter examples appear as the feasible alternatives. Either would, of course, require agreement of the appropriate state board and of the institutional authority to serve as a Center.

There has been general agreement at the board level as to the need to obtain efficiency in information systems and computerization throughout the state. Putting such agreement into practice, however, is extremely difficult in view of the competing demands on institutional leadership and resources. What would be unacceptable on a permanent basis might be acceptable temporarily — as for example, in the case of a major higher education institution should the higher education load become too great.

The functions of the Area Computer Center Boards would vary depending upon whether the Board actually operated a Center of its own or contracted, for example, to obtain computer service from an AVTS. In the first case, the Board would be in full charge of setting up and operating the Center. In the latter event, the Board would establish plans and priorities but would simply contract with the AVTS or its school district for services. The Center management would be responsible to the school district but would have to work closely with the Area Computer Center Board to assure customer satisfaction.

In summary, both higher educational institutions and AVTS's could serve as Area Computer Centers. Certain higher education institutions are better equipped presently to handle such an assignment and should serve local government at least in the developmental period of information systems and instructional computing. The AVTS's appear to be a better choice for permanent assignment as an Area Computer Center. A principal reason for this is that the AVTS's are almost certain to serve their school districts as well as others, a development that is inherent in the State Board of Education policy. Another important reason is the often close relationship of the AVTS's to the officials in their constituent communities. The recommendations for Area Computer Centers made later in this section are consistent with these conclusions.

ORIENTATION AND TRAINING

Information systems, involved as they are with the broad, complex, and largely innovative concepts of systems analysis and computerization, simply cannot be developed without a significant training effort. Curricula should be established for elected officials, for top and middle management, for supervisory personnel directly involved in services likely to be computerized, and for local government personnel who will form or be the coordinative link with, the information systems cadre.

These courses should include systems analysis, information and decision systems principles, and computer courses, all geared to the level necessary depending upon the function of the person. Courses should be offered in different areas in the state. Much of this could be on a rotating basis; but some courses, particularly for those persons deeply involved, should be offered through appropriate educational institutions, particularly, of course, those presently offering such courses.

Educational programs of value to local government information systems efforts should be catalogued and periodically disseminated to local government through the existing channels of the Association of Minnesota Counties, the League of Minnesota Municipalities, and the Minnesota Association of School Administrators.

Of equal or perhaps greater importance is the need for such emphasis in teacher training sequences. Recommendation No. 7 in Part IV of this report recommends "adding requirements to existing degree programs and certification standards in order to encourage pre-service training in computer science for teachers and educational administrators." That recommendation concludes with this sentence: "The major problem in implementing modern information systems and computer instruction technology in local school districts is a lack of people trained in these fields." That comment is borne out by the findings of the recent TIES evaluation report referred to in Section 2.

FUNDING

The key to initiation of the program outlined previously is, of course, financing. It appears unrealistic to expect developmental funding by local government alone. Some contribution, however, should be expected from local government, perhaps on a matching basis. TIES, for example, was financed initially in part by Federal funding.

Because the need is so great and the time so short, it is recommended that the State make available a substantial sum for developmental work. This money would be available for expenditure by order of the Director of Information Systems upon recommendation of the Intergovernmental Commission on Information Systems. The funds would be available for developmental purposes. In the main, they should be used to develop or obtain systems and to fund pilot projects, but they should not be available to subsidize an on-going service to a local government.

The amount recommended from the State budget for the next biennium is $1,000,000 for use in development of county and municipal information systems, $700,000 for school districts, and $200,000 as the initial budget for the Local Government Section. The county-municipality sum should be available for use through one or more Area Computer Centers on a matching basis (for example, $3 of State funds for $1 of local funds). The distribution between county and municipal systems should be determined by the Intergovernmental Commission with a principal criterion being early pay-off. (Some systems would be equally usable by either counties or municipalities.)

The school district distribution is suggested as a $1 augmentation of school aid per year (or $2 the first year) for all of the students in TIES, approximately 240,000, and all of the students in the second TIES-like Area Computer Center, assuming the new center covers approximately 100,000 students. The TIES suggestion is to give that organization support for accelerating its developmental effort and assumes that all TIES systems and programs would be available without charge to other Minnesota jurisdictions. The money would be made available by the Director of Information Systems to TIES and the new school district Area Computer Center upon recommendation by the Intergovernmental Commission after reviewing plans for development to be financed by the funds. The funds could be made available over a one or two year period. It is, of course, imperative that State Department of Education information requirements be met in any systems design undertaken by TIES or the other Center.

The amount of money recommended could easily be doubled and spent productively, particularly so long as the overall controls are being exercised by the Intergovernmental Commission and the Director of Information Systems. The odds are high that every dollar invested in this way will return an extremely rewarding pay-off to the taxpayers in Minnesota in the future — the near future.

It would be appropriate, of course, to seek Federal and foundation funding assistance for both of these efforts. Pooling of resources and efforts among the larger units of local government and the State in specific subject matter areas should also be attempted. For example, the Metropolitan Council has listed in its 1971 program a major effort on a metropolitan information system. As a further example, a school district might be willing to assist with financing a particular project to move it ahead on the priority listing.

To assure that requests for Federal or foundation funding for information systems or computerization purposes are consistent with overall plans and carry the potential for the most effective results, all such requests originating with local governments should be subject to the review and approval of the Intergovernmental Commission. This requirement should apply to such funds whether intended to be granted directly to a local government or to be channeled through an appropriate State agency.

The possibility of Federal funding should be aggressively pursued by the Commission, either as a Minnesota project or in combination with other states. Further, joint development action with other states should be explored. The Midwestern States Educational Information Project (MSEIP) is an example of the combination of joint action by the Federal government and several states, as is the Project SEARCH. The systems analysis and computer programs resulting from MSEIP are currently under careful review by the State Department of Education for possible use by school districts as well as the department itself.

IMPLEMENTATION SUGGESTIONS

Specific action to implement the general recommendations above is outlined below. These actions assume legislative adoption and enactment of the general recommendations made previously. An interim approach is also suggested so that development can proceed prior to such action.

1. The Intergovernmental Commission on Information Systems should authorize an Area Computer Center dedicated to the development and implementation of information systems for county and municipal governments. Although centers established later could well include school districts as well as counties and municipalities, the development effort for the latter two will take all the resources the Area Computer Center Board can marshall. (A second center, similar to TIES, is recommended below.) Selection of the area to be covered, preferably a region or a part of a heavily populated region, should be based on the criteria outlined earlier and on the interest and support available in the area. The Metropolitan Council, for example, might be an appropriate Area Computer Center Board to serve part of its seven county area. It is recognized that accomplishing this task may be difficult. However, the local government needs, the availability of some State and/or Federal funding, and significant State technical assistance should provide incentive to a group of progressive jurisdictions.
2. The Intergovernmental Commission should spell out its delegation of authority and assignment of responsibility to the Area Computer Center Board and then conduct an election for the Board.
3. The Area Computer Center Board should appoint a Standards Committee and a Systems Development Committee. The Standards Committee should undertake the sizable task of drafting a standards manual for local government in Minnesota, including among other things, a data dictionary. Every opportunity should be made available for other local government input. In particular, TIES, the Hennepin County data processing section, and the St. Paul-USAC project staff should be invited to contribute. Draft manuals should be circulated to all counties, all municipalities (over 2500 population), TIES, the Metropolitan Council, and the State Department of Education for review and comment. The initial standards manual should ultimately be presented to the

Intergovernmental Commission for approval and would then serve as the local government standards manual. The Local Government Section of the State Division of Information Systems should supply technical assistance in the standards manual development and should assure appropriate Federal and State coordination.

The Systems Development Committee should be heavily aided initially by the Local Government Section of the Division of Information Systems. The objective is to obtain or develop sound information systems. The systems selected for initial development should be those with greatest payoff Further, they should be capable of modular development so that payoff obtainable from part of the system may be realized promptly without having to wait for the completion of the entire system. As with standards, the systems design must be submitted to all jurisdictions for review. Local governments with particular interest, expertise, or accomplishment in related systems should be invited to participate in development of transferable information systems. It is expected that certain already successful systems or subsystems may be obtained free or by purchase from public or private agencies to speed payoff and eliminate the waste associated with redundancy.

4. In the initial stages, the Area Computer Center Board should make use of a computer capability other than its own. It is expected that only a sizable computer configuration can handle the information systems that will be developed. The Center simply could not utilize such equipment effectively at the outset. Prime candidates for such use include computers of the State Division of Information Systems and higher education institutions The selection of a site should be made in close consultation with the Intergovernmental Commission to assure consistency with the overall State plans and potential network in all areas of computerization. A totally new Center should be established only after exhausting the possibilities presented by existing facilities such as the AVTS's.

5. The implementation of all except the most proven of existing systems (such as payroll systems) should be limited to one user. That is, one new application would be tested with one user, another with another user, etc. Until extensive testing is completed, *no additional users* should be allowed to use a new application. Finally, comprehensive user's manuals *must* be in being prior to implementation.

6. The Area Computer Center Board should develop written policies, regulations, and procedures governing the operation of the Center including a model contract for services; input and output control requirements; security, privacy, and confidentiality of data; charging for services rendered; etc. These should be reviewed and approved by the Intergovernmental Commission inasmuch as they should serve as a pattern for other centers.

7. The Area Computer Center Board, in consultation with the Intergovernmental Commission, should establish an operating plan for the first two years and a corresponding budget.

8. Selection of a director for the center should be made by the Area Computer Center Board. Staffing of the center should be by the director subject to approval of the Board.

9. The Intergovernmental Commission should authorize a second Area Computer Center composed of school districts. Like the first center, it should preferably be based on a region (MESA). It is recommended that the Center be one of the AVTS computer facilities, providing a good test of the advantages and problems associated with having centers at those schools. It should utilize the TIES programs either as they are or reprogrammed to another computer, or it should obtain a comparable capability. An example of the latter is a combination of the Newport-Mesa (California) system for administrative systems and the

EDINET (Honeywell) time-sharing system for instructional uses. Another possibility to be researched is the end results of the MSEIP (Midwestern State Educational Information Project). In any event, the center *should not* begin from scratch but should use systems now operational although it may appropriately develop new systems not readily available under TIES or its alternatives.

INTERIM ACTION

Note that prior to legislative action, the State-Local Data Systems Group and the Local Government Unit of the Computer Services Division should lay as much groundwork as possible for the initiation of the foregoing program. This should include:

Initiating a search for strong existing computer systems and accompanying programs for county and municipal government which can be used as they are; can be modified to meet Minnesota local government needs; or, using the systems documentation, can be helpful in completing the design necessary for Minnesota local government.

Assuring the general applicability and acceptance of systems identified in (1) above.

- On a pilot project basis, initiating local government applications that would have priority and be widely applicable throughout the State.
- Beginning the development of a standards manual for local governments including among other items a data dictionary to assure uniformity in terminology; data element specification to assure standard length; programming language (for example, USASI, COBOL, and FORTRAN); data communication code structures; system analysis and programming documentation; feasibility study and report formats; cost accounting for information systems.
- Validation and completion of the data obtained from local governments in the course of this study and arranging for periodic update of the data.
- Establishing media and procedures for intergovernmental interchange of data.
- Developing policies covering confidentiality of data and procedures for carrying them out.
- Setting up procedures for reviewing proposals for federal, state, or foundation aid in developing information systems with local or intergovernmental impact.
- Recommending policies and procedures for charging for services rendered by area centers.

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